Vol. XXXVII MARCH, 1954 No. 10

THE PHILIPPINE AGRICULTURIST

UNIVERSITY OF THE PHILIPPINES PUBLICATIONS SERIES A

CONTENTS

Abacá Mosaic ..... *G. C. Kent* 555

The Influence of Sprinkler Irrigation on the Yield of Corn Grown From March to June .. *Edilberto A. Uichanco* 578

Chemical Composition of Certain Livestock Feeds ..... *L. A. Ynalvez, Lolita Austria, Epifania Cruz,* and *J. K. Loosli* 587

Outstanding Varieties and Forms of Pummelo, Citrus Grandis (Linn.) Osbeck, in Nine Towns of the Mountain Province ..... *Loreto G. Gomez* and *L. G. Gonzalez* 593

The Performance of the Ensilage Harvester ..... *Alejandro M. Catambay* and *Alejandro B. Catambay* 611

The Fungus Causing Black Kernel Rot of Corn ..... *Maria Salome E. del Rosario* 623

College and Alumni Notes 632

Published by

THE COLLEGE OF AGRICULTURE
AND CENTRAL EXPERIMENT STATION
UNIVERSITY OF THE PHILIPPINES

9 MAR 1955

The Philippine Agriculturist

(University of the Philippines Publications Series A)

Editor

L. B. UICHANCO, SC.D. ..... *Dean, College of Agriculture*

Managing Editor

G. O. OCFEMIA, PH.D. ..... *Professor of Plant Pathology*

Copy Editor

NORA J. CRUZ, A.B. ..... *Instructor in English*

Business Manager

JOSÉ M. CAPINPIN, PH.D. ..... *Associate Professor of Agricultural Botany*

Advisory Board

F. O. SANTOS, PH.D. ..... *Head, Department of Agricultural Chemistry*
VALENTE VILLEGAS, PH.D. ..... *Head, Department of Animal Husbandry*
FRANCISCO M. SACAY, PH.D. ..... *Head, Department of Agricultural Education*
LEON G. GONZALEZ, PH.D. ..... *Head, Department of Agronomy*
A. B. CATAMBAY, M.S. ..... *Head, Department of Agricultural Engineering*
SILVERIO M. CENDAÑA, PH.D. ..... *Assistant Head, Department of Entomology*
NICOLAS L. GALVEZ, PH.D. ..... *Acting Head, Department of Soils*

Authors of articles appearing in THE PHILIPPINE AGRICULTURIST are severally responsible for the opinions expressed therein.

THE PHILIPPINE AGRICULTURIST is published monthly, except in April and May, beginning with Volume 35, by the College of Agriculture and Central Experiment Station, University of the Philippines, Los Baños, Laguna. The subscription price is ₱6.00 a year in the Philippines and $4.00 (U.S. currency) elsewhere; the price of single copies, ₱0.75 in the Philippines and $0.50 (U.S. currency) elsewhere.

Business correspondence should be addressed to the Business Manager, THE PHILIPPINE AGRICULTURIST, College, Laguna, Philippines. All remittances should be made payable to THE PHILIPPINE AGRICULTURIST.

Communications for the editor should be addressed to the Editor, THE PHILIPPINE AGRICULTURIST, College, Laguna, Philippines.

Publications sent in exchange for THE PHILIPPINE AGRICULTURIST should be addressed: Library, College of Agriculture and Central Experiment Station, College, Laguna, Philippines.

Entered at the Post Office at College, Laguna, Philippines, as second-class mail matter.

ABACÁ MOSAIC [1]

G. C. KENT [2]

WITH FIVE TEXT FIGURES

Mosaic is the most destructive disease of abacá, the Manila hemp plant, in the Philippines. The disease is so destructive that many have forecast the complete ruin of the Manila hemp industry in the Philippines. In the view of many, high production is maintained only by the continued opening of new land for abacá culture, and as soon as all the land suitable to abacá has been opened the industry will die.

Such dire forecasts have stimulated the search for substitute synthetic fibers. Thus, the abacá industry stands to suffer not only from the direct effects of the disease but also from the competition of synthetic fibers which have been developed because the source of Manila hemp, the primary cordage fiber in the world, seems threatened (Anon., 1953).

The disease is a serious blow to the Philippines not only because of its effect on one of the major export crops but also because it threatens to wipe out the only native commercial plant in the country. The disease has been controlled in the past and can be controlled now. That control, as in the past, will depend primarily upon the initiative and perseverance of the growers and not on any government cure-all program.

An excellent review of the history and requirements of the abacá plant is given by Spencer (1953).

NAME

The disease was called mosaic because of the appearance of the infected leaves when Calinisan (1934) first reported the presence of the disease. Ocfemia (1937) used the same name for the malady in 1937. Reinking (1949) points out that while the disease resembles the infectious chlorosis of banana in Australia, it does not cause infection of banana in the Philippines. Hence, Reinking believes the different name should be retained.

At present, the name covers all mosaiclike diseases of abacá without regard to the particular virus concerned. The disease is, in fact, a complex which involves several viruses or virus strains.

SUSCEPTS

The range of suscepts of the disease or disease complex is, at present, confused. The susceptibility of a particular species depends on the vector and the source of the virus (Ocfemia, 1949).

---

[1] Central Experiment Station Contribution No. 1756.

[2] Visiting professor of plant pathology (1953-1954) from Cornell University.

[THE PHILIPPINE AGRICULTURIST, Vol. 37, No. 9, February, 1954, appeared in December, 1954.]
THE PHILIPPINE AGRICULTURIST, VOL. 37, NO. 10, MARCH, 1954

The primary source plants, that is, plants from which viruses causing mosaic in abacá can be vectored to abacá are as follows:

Abacá, *Musa textilis* Née (Ocfemia and Celino, 1938)
Canna, *Canna indica* L. (Ocfemia and Celino, 1938)
Corn, *Zea mays* L. (Celino and Ocfemia, 1941)
Cowpea, *Vigna sinensis* (L.) Vahl. (Anon., 1949; Ocfemia, 1953)
Panicum colonum L. (Castillo, 1953)
Arrowroot, *Maranta arundinacea* L. (Castillo, 1953)
Seedy Musa, *Musa* spp. (Castillo, 1953)

Several secondary source plants are known to date. These are plants harboring viruses that can cause mosaic in abacá only after they have become established in one of the primary source plants or suscepts. From these primary source plants the virus may be vectored to abacá. The known secondary source plants are the following:

Culapé, *Paspalum conjugatum* Berg. (Ocfemia, 1953) (Via canna for corn)
Crabgrass, *Digitaria sanguinalis* (Linn.) Scop. (Ocfemia, 1953) (Via corn)
Sugar cane, *Saccharum officinarum* L. (Ocfemia, 1953) (Via corn)
Cogon, *Imperata exaltata* Brongn. (Ocfemia, 1953) (Via corn)
Panicum colonum L. (Castillo, 1953) (Via corn; also a primary source)

The virus causing mosaic in *Canna indica* can be taken to *Canna edulis* and at least two varieties of ornamental Canna. The same virus, when in abacá, is not transferred to *Canna edulis* nor to the ornamental varieties. Likewise, there is no evidence that the virus can be transferred from *C. edulis* or the ornamental varieties to abacá (Ocfemia, Macaspac, and Hsieh, 1941).

The virus has been transmitted from abacá to *Crotalaria juncea* L., but not from the infected *Crotalaria* back to abacá (Castillo, 1953; Agati, 1953).

The following species have not become infected by the abacá mosaic virus: cucumber; cotton *(Gossypium* sp.); banana varieties Latundan (*Musa sapientum* var. *cinerea* [Blanco] Teodoro), Lacatan (*Musa sapientum* var. *lacatan* [Blanco] Teodoro), Buñgulan (*Musa sapientum* var. *suaveolens* [Blanco] Teodoro), and Saba (*Musa sapientum* var. *compressa* [Blanco] Teodoro); camia (*Hedychium coronarium* K.); *Canna edulis* Ker.; and *Canna* spp. (Celino, 1940; Juliano, 1951).

The transmission of the virus by insects from the following species to abacá has failed: *Hippeastrum* spp., *Centrosema pubescens,* liñga (*Sesamum orientale* L.), mani-manihan, and *Canna glauca* Linn. (Juliano, 1951; Agati, 1953). It should be noted that transfer via corn or *Canna indica* has not been tested in these cases.

Mechanical transmission of mosaic viruses to abacá has failed in tests using for the source of the inoculum ampalaya (*Momordica charantia* Linn.), banana, ornamental canna, *Canna indica* Linn., *Eucharis grandiflora* Planch., *Hippeastrum* spp., *Panicum* sp., culapé

(*Paspalum conjugatum* Berg.), pechay (*Brassica juncea* [Linn.] Coss.), sugar cane, corn, and tobacco (Juliano, 1951).

HISTORY

The mosaic disease of abacá was first reported by Calinisan (1934) following his observation of the Odell Plantation in Davao, Mindanao, on March 7, 1933. Calinisan was at the time directing the program for the control of bunchy-top of abacá. The disease was undoubtedly present earlier, but its actual origin is unknown. It was again reported by Ocfemia in 1937 as causing widespread damage.

During the period 1933 to 1942, the disease was kept under control by the destruction of diseased plants and by proper cultural practices in the plantations (Reinking, 1950). The potentialities of the disease were evidenced as early as 1937 when plantations in eastern Davao which were not properly managed showed as high as 50 per cent infection (Ocfemia from a conference with Mr. U. Kojima of the Ohta Development Company in Davao; Celino, 1940).

After the liberation in 1945, the large plantations formerly owned and operated by the Japanese became the property of the Philippine government. Neither the Philippine government nor private owners, in many cases, were able to bring the abacá plantings, which had been abandoned for two to three years, back under good cultural practices. In addition, squatters and roving bands of strippers overstripped many plantations. As a result the mosaic disease became critical throughout the Davao area.

A third factor responsible for the marked increase of mosaic following liberation was the lack of knowledge about the disease. Hemp prices were abnormally high and the planting of abacá was increased many fold. Most of the new plantings, unfortunately, were made with diseased eyes, corms, or suckers. Again because of overplanting, culture was not good and further spread of the disease was rapid (Reinking, 1950).

Ocfemia was called to Davao in 1937 to look into the bunchy-top and "unknown" diseases of abacá. During his visit he noticed the similarity of the mosaic in abacá and in wild canna, *Canna indica*. Proof of his suspicion opened the field of other suscepts and their relation and importance to the disease (Ocfemia, 1937).

The importance of aphid vectors was proved by Ocfemia and Celino in 1938 (Ocfemia and Celino, 1938). Until that time the only known method of increase had been through diseased planting materials.

Because of the serious damage to the hemp industry as evidenced by falling production, when ECA aid from the United States was started in 1950, one of the first problems to receive attention was the abacá mosaic disease. Dr. Otto A. Reinking, a former professor at the College of Agriculture who had had a great deal of experience

with plant diseases in the tropics, was asked to set up a control program. He arrived in the Philippines in May, 1950. The program was initiated on October 7, 1950, and continued until December 31, 1953.

IMPORTANCE

The increasing importance of mosaic to the hemp industry is best indicated by the trend of reports about the disease.

In 1933, Calinisan (1934) counted 36 mosaic hills and determined the percentage of infected stalks in the hills.

In 1938, Ocfemia and Celino (1938) reported mosaic as less destructive than bunchy-top, but warned that if not controlled it could become more destructive than bunchy-top.

Celino (1940) cited a report by Kojima stating that in the eastern part of Davao infection had reached 50 per cent.

Reinking (1949) considered mosaic the most serious disease of abacá and cited the grave threat to the industry. In some areas, the percentage infection had reached 100. Within the next year a marked increase in the spread of the disease was noted (Reinking, 1950).

Reinking (1950) compared the yields of abacá fiber in two areas. In the heavily infected area around Calinan, 22,577 hectares with 2 to 85 per cent infection produced 10,000 piculs/mo. or 0.44 piculs fiber/ha/mo. In the Compostela area with infection averaging 4 per cent, the production was 7800 piculs/mo. or 1.5 piculs/ha/mo.

In 1953, with a 30 per cent increase in area planted, the total production of hemp dropped by 6 per cent. Much of the drop is traceable to the effect of mosaic.

In 1953, in spite of the Mosaic Control Program, many large growers forecast the early destruction of the industry because of the disease. These growers not only called for an increased and prolonged government program but also stimulated the synthetic fiber industries to try to find a substitute for abacá fiber.

The mosaic disease causes losses in many ways. The fibers produced by diseased plants are fewer and shorter and are reported to be much weaker (Agati, 1953). The infected plants require a longer time to mature so that the annual production per hectare is reduced. hectare. These effects may all be traced to the reduced size of the These effects may all be traced to the reduced size of the leaves and the failure of full chlorophyll development in many of the leaves.

Because of the smaller, slower growth, the canopy is opened and the growth of weeds is increased. The resultant weed growth further lowers production through increased competition or increased spread of mosaic or both (Agati, 1953).

An additional reduction in income results from the cost of renewing and replanting the infected hills.

SYMPTOMS

The symptoms of mosaic in abacá consist of pale-yellow to light-green streaks running parallel to the veins between normal green tissues. The symptoms may occur on the leaf blade, midrib, petiole, pseudostem, inflorescence, and fruit. In the late stages the yellowish areas become rusty to dark brown. The symptoms appear to vary somewhat from variety to variety and among the strains of virus in any one variety. This apparent variation needs intensive study to allow strain determination from the particular syndrome.

Leaf blade. The first symptom appears on the unrolling leaf blade as pinhead-sized, pale or whitish dots about eight to ten days after inoculation. These dots soon elongate, parallel to the veins, to produce short, narrow, spindle-shaped dashes (fig. 1, left). The

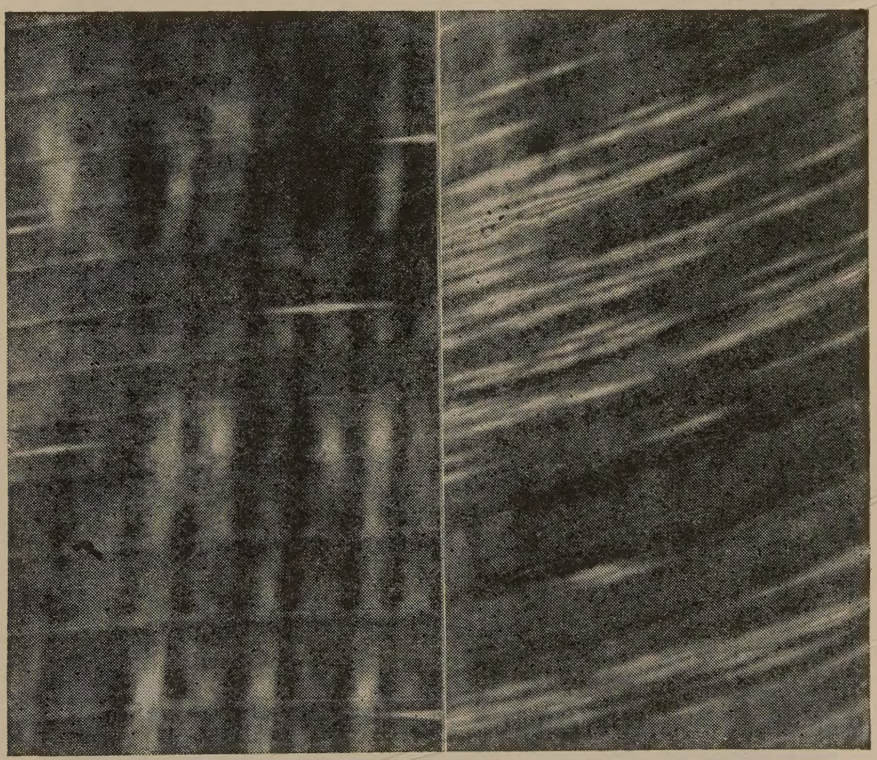

Fig. 1.—Left, a part of abacá leaf showing five of the earliest symptoms of abacá mosaic consisting of yellowish-white, short, and narrow spindle-shaped dashes. Note that the white central dot of the five spindle-shaped dashes can still be distinguished. Right, a more advanced stage of infection showing the running together of two or more dashes. (*Photographed by the Photographic Division, College of Agriculture.*)

original central dot is still evident as an eyelike center of the spindle-shaped lesion (Ocfemia and Celino, 1938).

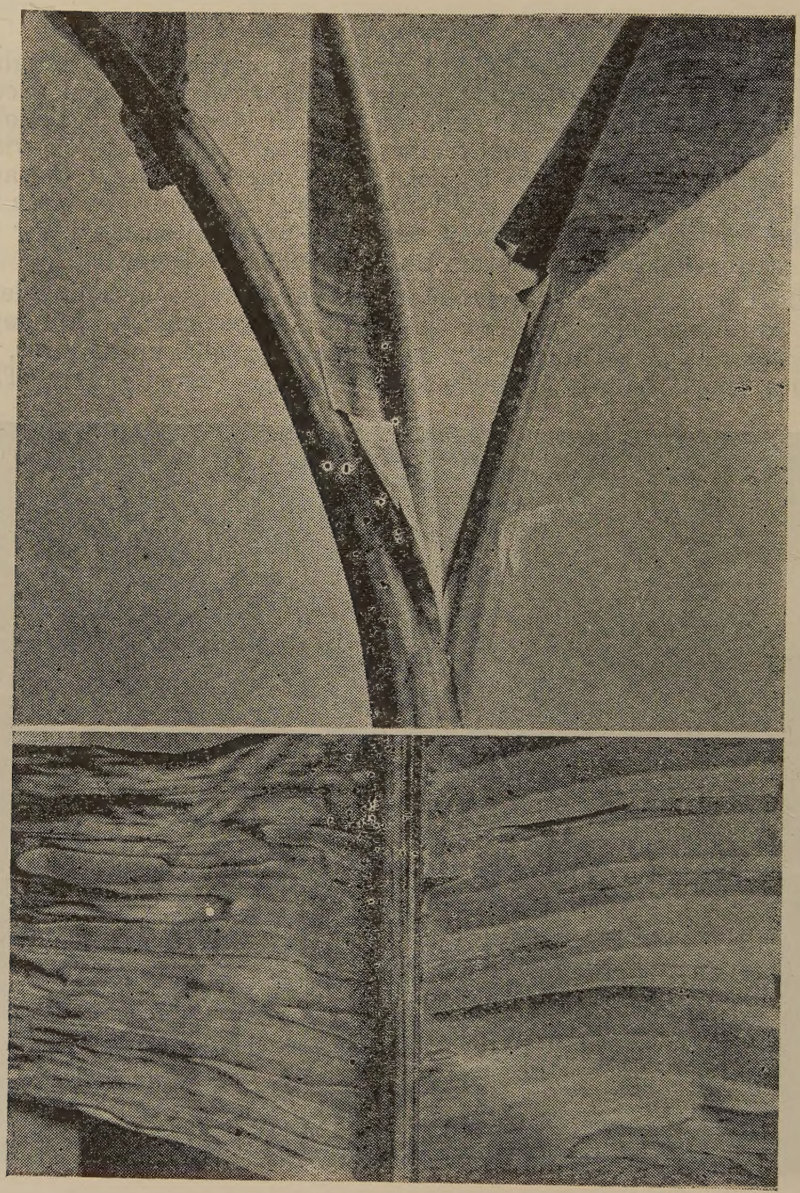

Fig. 2.—Upper panel, an abacá plant infected with mosaic showing the yellowish-white streaks on the furled and expanded leaves and on the petioles. Lower panel, back view of part of leaf of abacá infected with mosaic disease showing the purplish-brown streaks running lengthwise with the midrib. Similar purplish-brown streaks on the expanded leaf immediately replace the yellowish-white streaks. These purplish streaks expand in both directions, though faster in the direction of the veins, turn brown, and dry up; their borders remain distinctly brown. Before the death of the yellow streaks, the upper side of the leaf presents a purplish tinge. (*Photographed by the Photographic Division, College of Agriculture.*)

The next leaf shows similar elongate eye-spot lesions at the base, with an increasing number of more definite, elongate, yellowish patches (fig. 1, right) toward the middle and top of the leaf. These patches are 3 to 5 mm. wide and 20 to 30 mm. long (Celino, 1940).

The tip of the second leaf or the third leaf bears the typical mature symptom. This consists of numerous distinct, narrow, pale-yellow, stripelike lesions between normal green areas (fig. 2, upper panel). The lesions extend from the midrib to the edge of the leaf parallel to the veins and are often limited by the veins (Celino, 1940; Reinking, 1949). As the leaf becomes older, the lesions become rusty brown, first at the edges and later all over.

In some cases the leaves when fully unrolled show a more or less marked blistering or corrugation (fig. 3, right). The corrugation

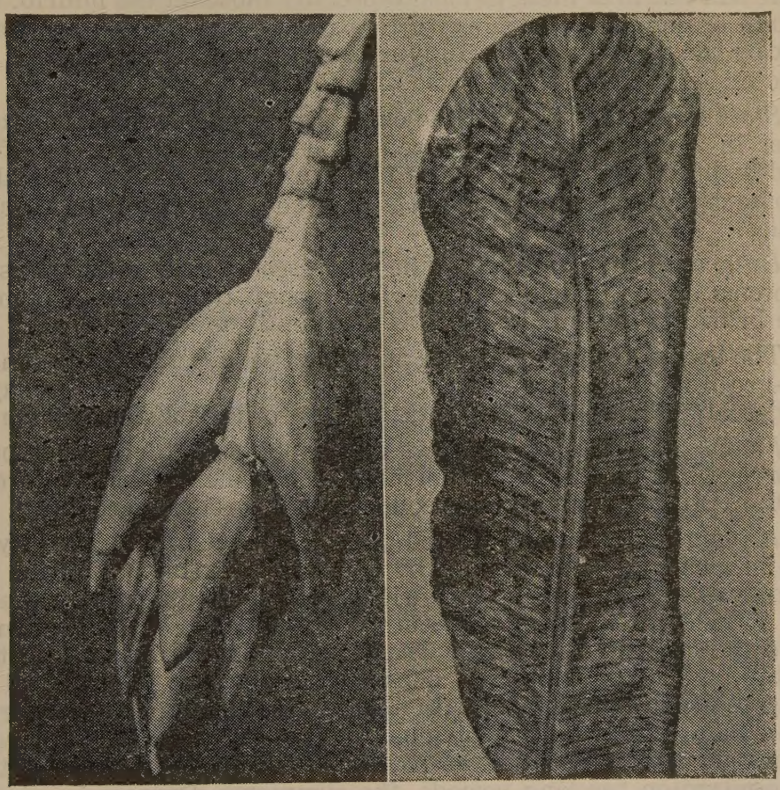

Fig. 3.—Left, the heart of a mosaicked abacá showing indistinct whitish streaks on the bracts and peduncle. Right, a leaf of mosaicked abacá showing the curling along the margins, the puckering of the expanded portion of the leaf, and the curved midrib. (*Photographed by the Photographic Division, College of Agriculture.*)

seems to consist of nearly square areas arranged in rows extending parallel to the midrib (Reinking, 1949).

In fully infected plants the unrolling leaf blade shows wide bands of pale-yellowish, nearly white, or bleached streaks or areas (fig. 2, upper panel). As the leaf unrolls these areas become greener. A slight clearing of the veins may be seen in the unrolled leaves, but this is not observed in the rolled leaves. The vein clearing in a fully expanded leaf is a characteristic symptom of bunchy-top.

Midrib and petiole. The midrib and petiole of yet unfolded leaves show water-soaked, elongate lesions. These lesions, elongated parallel to the midrib, tend to bunch together and differ from lesions on the blade in that the ends tend to be square. As the leaf unrolls the lesions become light yellow. In some cases the lesions seem to be darker green with light-yellowish borders (fig. 2, upper panel). As the leaf matures these lesions, especially those on the midrib, turn through orange and rusty brown to a dark brown, becoming almost black by the time the leaf is fully mature (fig. 2, lower panel). The tissue under these streaks is also discolored.

Stalk or pseudostem. If the outer leaf sheath is removed from a sucker in a diseased hill the second and subsequent sheaths of the pseudostem show yellowish-white to purplish streaking or mottling. In some cases necrotic brown spots may be observed in the vascular bundles.

Inflorescence or "heart." The inflorescence stalk shows the same symptoms as the midrib and petiole although the lesions seldom become brown. The inflorescence is frequently much dwarfed.

The bracts are paler in color and show yellowish or, occasionally, light-green mottling or streaking (fig. 3, left). The streaks may be broader at the base of the bract, tending to narrow toward the tip.

Fruit. The fruit often shows no symptoms. It may show purplish wedge-shaped streaks or mottling. The inner tissues are brown, and the fruits are small and frequently fail to ripen seeds.

A plant grown from infected planting material will show symptoms in all its parts and will show marked dwarfing. A plant that becomes infected after it is set will show symptoms only in the tissues formed after infection occurs. The older the stalk when infected the less the dwarfing. The virus will move into all parts of the hill, and symptoms will subsequently be observed in all the younger suckers connected with the infected stalk. The dwarfing of the inflorescence is proportional to that of the stalk as a whole (Calinisan, 1934; Castillo, 1952). In a few cases of plants kept under observation for long periods, the symptoms decrease in severity and the dwarfing decreases in some stalks. Complete recovery has never been observed.

The symptoms of canna mosaic in abacá differ somewhat from those of the true abacá mosaic (fig. 4, right). The canna virus seems to produce more irregular stripes on the leaves (fig. 4, left),

and the leaves show more wrinkling and curling (Ocfemia, Macaspac, and Hsieh, 1941). The symptoms on other hosts tend to be those of mosaic in the particular species. The variation in such symptoms has not been investigated (Lawas and Fernandez, 1948).

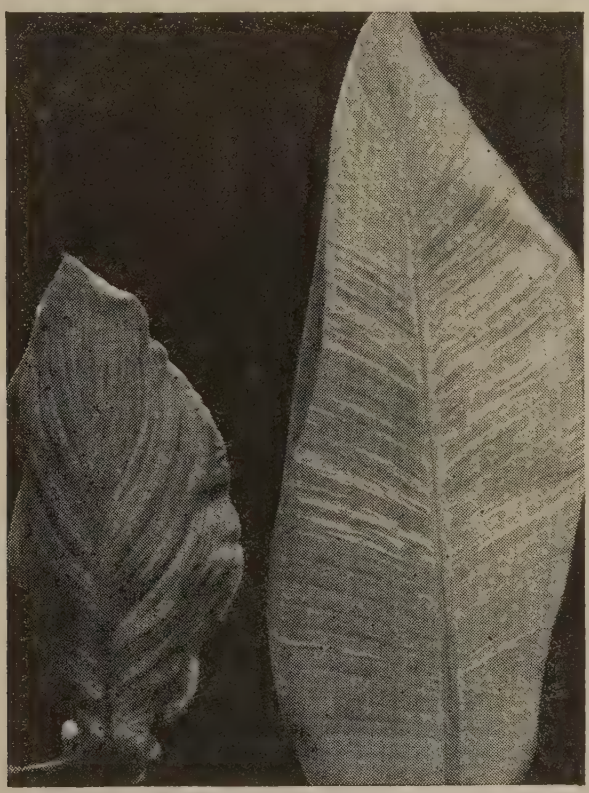

Fig. 4.—Left, a leaf of the wild canna (*Canna indica* Linn.) infected with the mosaic disease which is transmitted to abacá by the cotton aphid (*Aphis gossypii* Glover) or the corn aphid (*Aphis maidis* Fitch). Right, a leaf of abacá showing the long yellowish-white streaks of mosaic disease running parallel with the veins from the midrib to the margin of the leaf. (*Photographed by the Photographic Division, College of Agriculture, September 12, 1951.*)

ETIOLOGY

Name and classification of pathogen. The mosaic disease of abacá is undoubtedly a complex. This is indicated by the information on host plants and the transmission of viruses from grasses to abacá with the resultant production of mosaic and by the slight differences in symptoms of such "mosaics" in the abacá. Any of several viruses or virus strains seems able to produce mosaiclike symptoms in abacá.

The first proof of the virus nature of the disease was obtained by Ocfemia and Celino in 1938. Holmes (1939) suggested that the abacá mosaic might be caused by *Marmor cucumeris*, the virus causing cucumber mosaic, or specifically the variety *commelinae*. He perhaps accepted the suggestion of Calinisan (1934) that the abacá mosaic is similar to, if not identical with, the virus disease of banana reported by Magee (1930) from Australia. This designation was accepted by Ocfemia, Celino, and Garcia (1947) and by Reinking (1949). In the revision of his classification of the viruses, Holmes (1949) does not mention the abacá mosaic virus.

On the basis of present information it seems likely that at least five viruses are concerned, the viruses of the true abacá mosaic, corn mosaic, sugarcane mosaic, canna mosaic, and grass mosaic. Some of them may be strains of one virus. The virus from the legumes may also be different, and there may be more than a single virus causing the mosaics of the different grasses. The investigation and characterization of these viruses is one of the most pressing problems of abacá mosaic.

Ocfemia, Celino, and Garcia (1947) demonstrated that the mosaic virus and the bunchy-top virus are distinct viruses vectored by different aphids and that either one fails to protect the abacá plant from infection by the other. In mixed infections either virus can be recovered pure by using the appropriate vector.

Pathogenicity. The mosaic of abacá was assumed to be of virus nature from the first by Calinisan (1934) and Ocfemia (1937). Both of these authors and Celino (1940) attempted transmission by mechanical means and with the aphid *Pentalonia nigronervosa* Coq., the vector of the bunchy-top of abacá, but they failed in all cases.

In 1938, Ocfemia and Celino (1938) first obtained transmission and proved the virus nature of the disease using the cotton aphid, *Aphis gossypii* Glover. These authors reported a single case in which virus transmission was apparently obtained by maintaining contact for 28 days between the wounded midrib of a diseased plant and the wounded midrib of a healthy plant. The transmission was never confirmed in further tests and no other evidence of mechanical transmission has ever been obtained (Juliano, 1951). The virus nature of the causal agents has been shown many times since then in a number of trials using several vectors and a number of host plants.

In addition to *A. gossypii*, abacá mosaic can be transmitted from abacá to abacá by *Rhopalosiphum nymphaeae* (Linn.) (Celino, 1940), by *Rhopalosiphum prunifoliae* Fitch (Celino and Ocfemia, 1941), and apparently by *Proutista moesta* Westwood (Castillo, 1953; Agati, 1953). The transmission of the virus from abacá to abacá by *Aphis maidis* Fitch (fig. 5) seems not to have been tested.

The corn mosaic virus can be transmitted to abacá and back to corn by *Aphis maidis* Fitch (Celino and Ocfemia, 1941). The cotton

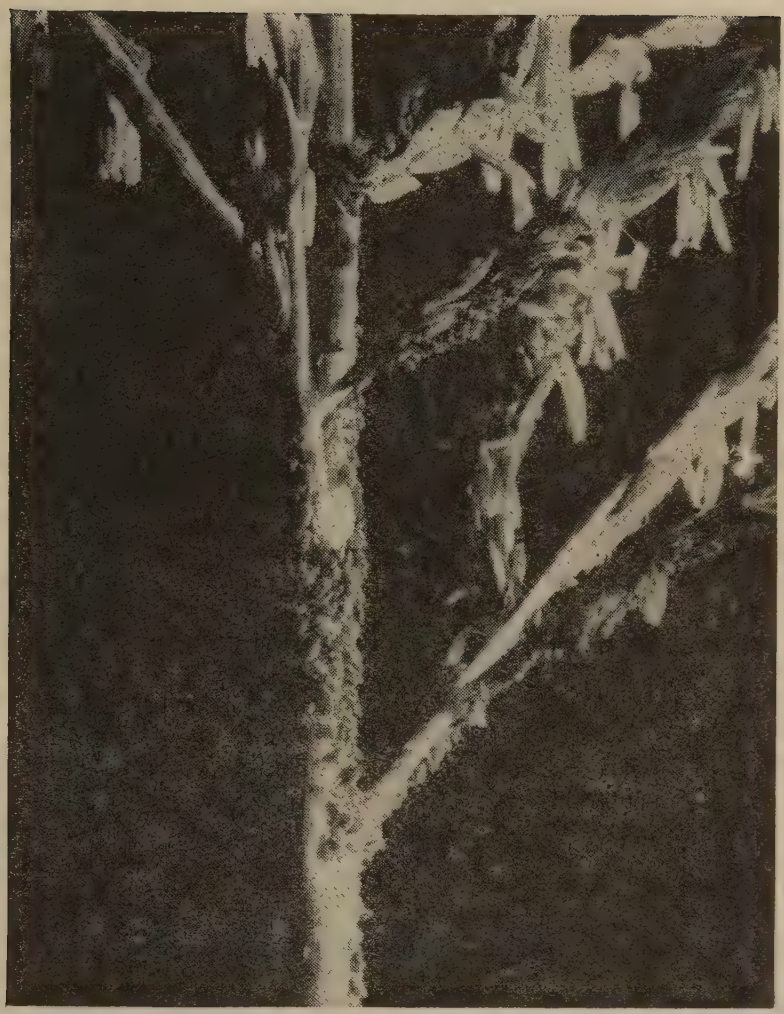

Fig. 5.—A tassel of corn showing an abundance of the corn aphid (*Aphis maidis* Fitch), one of the four known vectors of the abacá mosaic virus. (*Photographed by the Photographic Division, College of Agriculture.*)

aphid can transmit the corn mosaic virus to corn, but apparently not from corn to abacá (Ocfemia, 1949).

Aphis maidis can transmit the abacá mosaic virus from abacá to corn and back to abacá (Ocfemia, 1949).

The canna mosaic virus can be transmitted by the cotton aphid (*A. gossypii*) from *Canna indica* to abacá to *C. edulis* and two varieties of ornamental canna, and from abacá back to *Canna*. The cotton aphid cannot vector the virus from abacá to *Canna edulis* or

the ornamental varieties (Ocfemia and Celino, 1938; Ocfemia, Macaspac, and Hsieh, 1941).

The virus of cowpea mosaic can be transmitted from cowpea to abacá by the corn aphid, *A. maidis.*

The viruses present in naturally infected *Panicum colonum,* arrowroot (*Marantha arundinacea*), and agutay (*Musa* sp.) are readily transmitted to abacá by the corn and cotton aphids (Agati, 1953; Castillo, 1953).

The virus of culapé (*Paspalum conjugatum* Berg.) is vectored to corn by the cotton aphid.

Viruses in several plants cannot be transmitted directly to abacá but via an intermediate host. The corn aphid transmits the virus of mosaic in culapé (*P. conjugatum*) to *Canna indica* and from *Canna indica* to abacá, but apparently not from culapé to abacá.

The cotton aphid and the corn aphid can transmit the mosaic virus from crabgrass (*Digitaria sanguinalis* [Linn.] Scop) to corn and from corn to abacá, but not from crabgrass to abacá (Ocfemia, 1953).

The corn aphid can also transmit the mosaic viruses from sugar cane (*Saccharum officinarum*) and cogon (*Imperata exaltata*) to corn and from corn to abacá, but not from sugar cane or cogon to abacá (Juliano, 1951; Ocfemia, 1953).

The mosaic virus in *Panicum colonum* can be transmitted by the corn aphid to corn and then to abacá, as well as directly from *P. colonum* to abacá (Castillo, 1953).

These and other vector relations are shown in table 1. The important feature of the table is the number of the blank spaces which indicate no work on which to base any consideration. Most of the blank spaces in the table indicate relations which need clarification soon from adequate experimentation.

The following insects have been shown not to be vectors of the viruses causing mosaic in abacá: *Pentalonia nigronervosa* Coq. (the vector of bunchy-top of abacá), *Stephanitis typica* (Distant), *Ferrisia virgata* (Cockerell), and *Aphis laburni* Kaltenback (Calinisan, 1934; Ocfemia and Celino, 1938; Celino, 1940; Celino and Ocfemia, 1941; Ocfemia, Macaspac, and Hsieh, 1941).

Life history. The abacá mosaic appears to consist of a continuous series of secondary cycles. The absence of a dormant period in the growth of the host plants eliminates the practical possibility of any primary cycles. There appears, therefore, to be no basis nor value in considering the disease cycle as other than a series of secondary cycles.

While the introduction of the virus into a previously virus-free plantation can possibly be considered as a primary cycle, the facts of such an introduction differ in no way from the ordinary cycles. Hence, no advantage is to be gained from the introduction of such

a complication. The disease is best considered, therefore, as a series of succeeding cycles that differ in no essential respects.

Inoculation. The inoculation of a healthy abacá plant occurs only by means of one of the insect vectors. No evidence has ever been obtained of inoculation by any other means (Calinisan, 1934; Ocfemia and Celino, 1938; Juliano, 1951).

An insect, one of the four aphids or the leaf hopper, having picked up the virus from a diseased plant (abacá, canna, corn, cowpea, etc.), is moved to a healthy abacá plant and begins to feed. Under Mindanao conditions the winged forms of the aphids are seldom produced. The movement of these aphids from plant to plant results almost entirely from the activities of the ants. At least two species of ants are known to function in this "herding" of the aphids —the fire ant, *Solenopsis geminata* var. *rufa*, and the common black ant, *Dolichoderus bituberculatus* (Celino and Ocfemia, 1941; Agati, 1953).

The aphids do not readily colonize on the abacá and do not feed immediately. When feeding, they thrust their stylets either through the stomatal pores or directly through the epidermis into the leaf tissues. The stylets are passed between the cells or occasionally through the parenchyma cells to reach the phloem on which the aphids feed. Feeding occurs normally only on the undersurface of the leaf and primarily on the younger leaves (Celino, 1940).

The details of inoculation have been studied with only two of the aphids, *Rhopalosiphum nymphaeae* and *Aphis gossypii*. The aphids must feed on a diseased abacá plant for about two hours in order to pick up the virus. Five *A. gossypii* or eight *R. nymphaeae* are sufficient to introduce an adequate supply of virus into a plant to cause infection. A single aphid cannot apparently introduce sufficient virus. Having become viruliferous, the aphids need feed on a healthy plant for only five minutes to inoculate it. This feeding must occur soon after the feeding on the mosaic plant since fasting for one hour appears to result in the loss of the virus. Likewise, only one transfer occurs at a time. After having fed once on a healthy plant, the aphids appear to lose the virus and cannot transfer it until after they have again fed on a diseased plant. It should be remembered that if the aphids do colonize on the inoculated plant, those still feeding on that plant will become viruliferous after the incubation period has passed (Celino, 1940; Ocfemia, Macaspac, and Hsieh, 1941). The virus is not transmitted from the adult to the young aphid (Celino, 1940).

No detailed studies have been conducted on the leaf hopper, *Proutista moesta*. The report of transfer by it needs to be confirmed and carefully studied. The leaf hopper, because of its movement from plant to plant, may be more important than the aphids in the rapid spread of the disease within a plantation and from one plantation to another.

The spread of the virus through the use of diseased suckers or corms is a vegetative splitting of a diseased individual. It does not constitute inoculation; hence, it will be discussed under infection.

Incubation. Nothing is known about the true incubation phase of the disease. It is assumed that the virus is introduced through the proboscis into the phloem. Once in the phloem virus multiplication and establishment must occur within a short period of time. This entire phase of the cycle is free from any environmental effect.

Infection. The latent period of infection is assumed to begin with the feeding of the infective insect and to end with the appearance of symptoms. Since it is known that the feeding of the infective insect need not be longer than five minutes, the true incubation period cannot be determined.

Tests indicate that with *Aphis maidis* on abacá the latent period is from 8 to 10 days. With the grass aphid, *R. nymphaeae,* it ranges from 7 to 15 days. With *A. maidis* as the vector the latent period in corn ranges from 4 to 13 days (Celino, 1940; Celino and Ocfemia, 1941).

The viruses from other plants seem to have different latent periods. The latent periods in abacá of different viruses from different sources are as follows: arrowroot mosaic, 11 days; corn mosaic, 17 days; *Canna indica* mosaic, 18 days; *Panicum colonum* mosaic (direct), 30 days; seedy *Musa* spp. mosaic, 33 days; and cowpea mosaic, 104 days (Castillo, 1953).

The latent period of the grass mosaic virus which has passed through an intermediate host lies within this same range. Thus, from *Panicum colonum* via corn, the period is only 19 days; crabgrass via corn, 42 days; and culapé via canna, 32 days (Castillo, 1953).

The virus once introduced into abacá multiplies and spreads rapidly. After symptoms have appeared on a leaf, all subsequently formed parts show the mosaic symptoms. While a noticeable decrease in intensity of symptoms has been observed in rare instances, there have been no recorded cases of recovery (Reinking, 1949).

The infected plants usually become stunted after 8 to 12 months. This stunting may be severe: if the plantation is well kept, severe stunting may not occur until later. The plants rarely die unless attacked by other diseases.

While the virus spreads to all vegetative parts of the plant, it has never been found in the seed.

The rate and extent of spread of the virus in an abacá hill become of extreme importance in the selection of "seed." Since planting is by means of suckers, eyes, corms, etc., the use of diseased planting material is the primary and most important way of introducing the virus into new plantations or areas. It is frequently difficult to spot the disease in the eyes or "peepers" and, hence, knowledge of the spread of the virus becomes of great importance.

The virus spreads throughout the entire vegetative body of the infected clump. From observations of the disease it appears that this movement is slow when infection occurs in nearly mature stalks and more rapid in younger stalks. The closer a sucker is connected to the infected stalk, the quicker it becomes infected.

In the variety of abacá examined, the plants begin to separate into clumps below the ground when they reach approximately ten months of age. The age may vary in other varieties. In a plant less than 10 months of age, the daughter stalks still have underground connections to the mother, and the virus will spread to all stalks. Any sucker taken from such a clump is likely to be or become diseased.

After 10 months of age the hills begin to separate into clumps that are no longer attached to the mother corm or to each other. Each such clump has several stalks and suckers. The virus, in the absence of insects, does not pass from one clump to another if infection occurs after the separation is complete. Thus, a sucker taken from an infected clump has the virus, though not evident, whereas a sucker from an uninfected clump in the same hill remains healthy. The only way to determine the nature of the clumps is to excavate the hills and carefully separate the clumps (Castillo, 1952).

An apparently healthy sucker or eye taken from a diseased clump is a dangerous source of inoculum whether used in setting up a new plantation or as a replant in an established plantation. It is the use of such diseased planting stock, frequently taken with no attention to possible infection, that has been chiefly responsible for the rapid spread of the disease into new areas since 1946.

The selection of apparently healthy "peepers" from a healthy clump in a diseased or weedy plantation or in one with corn or canna in it may not be safe. Since the aphid vectors prefer to feed on the tender leaves of such "peepers," they may be infected but still not show the disease, the latent period not being up. The latent period in such young suckers is not known but is undoubtedly much longer than 14 days. It is also known that injury to the sucker in transplanting further delays the appearance of symptoms after the sucker has been set (Ocfemia, 1949; Reinking, 1950).

Saprogenesis. There is no known stage in the cycle of the disease in which the virus can maintain itself in dead plant tissue. Hence, dead plant parts are no longer sources of inoculum.

EPIPHYTOLOGY

So far as is known, temperature, humidity, rainfall, etc. have no direct effect on the virus or on the appearance of the disease. The soil is suspected of indirectly influencing the latent period and the type of symptoms, but such relationships have not been worked out.

There are factors of the biological environment that greatly affect the course of the disease, particularly the rate of spread. The interplanting of corn with abacá causes a marked increase in the amount and rate of spread of mosaic. In some cases, the mosaic in-

creases to 100 per cent in one year. The corn not only acts as a reservoir for the virus but is one of the most favorable host plants for the breeding of the aphids. When the corn dies or is harvested, the aphids move or are moved on to the abacá and carry the virus with them (Ocfemia, 1950; Agati, 1953).

The presence of canna, especially the wild canna, in or near abacá has the same effect. In fact any weeds, including grasses, allowed to grow in or around abacá are dangerous as sources of virus and as breeding places for the aphids. As soon as the weeds are cut or their growth slows down because of maturity, drought, etc., the aphids move to the abacá. Certain cover crops, such as perennial mungo, common mungo, Centrosema (*Centrosema pubescens*), Pueraria (*Pueraria phaseoloides* [Roxb.] Benth.), etc., that can be used to hold down weeds and provide green manure do not harbor the virus nor serve as particularly good hosts for the aphids (Anon., 1953).

The rate of spread in a plantation depends to a large extent on the number and kind of plants present that harbor the virus. Thus, the biological environment is far more important than the physical environment.

CONTROL

The control of mosaic of abacá is a difficult exercise of persistent, detailed action on a community basis. It depends upon attention to minute details and proper timing of activities. Because of its complexities, the disease can never be eradicated. It may be brought under control only by vigorous action on the part of growers fully cooperating with governmental agencies. Control can never be accomplished by the government alone.

The history of the Abacá Mosaic Control Campaign (Reinking, 1950a, 1950b, 1951a, 1951b, 1952a, 1952b; Agati, 1953) is too involved to be detailed here. It is an object lesson in disease control. The program was soundly designed and was conducted in a thoroughgoing manner.

The program of control consisted essentially of eight activities:

1. Survey of control areas having over 30 per cent infection to determine feasibility of their being brought under control.
2. Removal and destruction of diseased plants in surveyed control areas.
3. Resurvey and removal of infected plants.
4. Suggestion of proper cultural practices.
5. Development of disease-free seed banks.
6. Establishment of quarantine regulations for the protection of new areas.
7. Initiation of educational program among the growers.
8. Establishment of research program.

That the disease has not been fully controlled and that the program is considered a failure by many growers is the result, primarily, of three factors:

1. The erroneous use of the word "eradicate."
2. The failure of the growers to wage the control campaign.
3. The tremendous, unpredictable expansion of new areas planted to abacá.

In the operation of the campaign the term "eradicate" came to be used. The grower assumed that once a government survey party had gone through his plantation and removed the diseased plants, the disease was "eradicated" from his plantation. The grower naturally considered the program a failure when he saw new diseased plants in his plantation. It was not made clear to the growers that the control crews were eradicating the diseased plants, not the disease. Eradication of the disease under the conditions in Mindanao is impossible.

For reasons not entirely evident, many growers did not cooperate fully in the control program. After the survey crews had finished with a plantation, the grower, having the mistaken idea that the disease had been eradicated in his planting, failed to strictly apply the necessary control practices, and the disease increased.

The unprecedented expansion of the abacá plantings introduced complications that could not be handled immediately. Disease-free seeds could not be made available at once and many new planters, unaware of the importance of disease-free planting stock, purchased and planted materials having a high percentage of infection. These new plantings, interplanted with corn, provided nearly perfect conditions for the rapid spread of the disease. Attempts to protect new areas from the introduction of diseased planting stock through quarantine measures were defeated by smuggling on a large scale.

A good example of the difficulties of such a program is offered by the experience with bunchy-top of bananas in New South Wales. For the control of this virus disease, all plantations and acreages were completely destroyed in 1927. After complete destruction, replanting was permitted in 1928 with known disease-free suckers. In 1935, because of low returns partly caused by overproduction, control practices were relaxed and the disease began to spread again. Realizing the seriousness of the situation, the growers organized and developed a scheme to finance control in the worst plantations. The disease has now been controlled in that way (Cann, 1952).

The control of abacá mosaic depends on the cooperative application by the government and the growers of measures of exclusion, eradication, protection, and ultimate immunization.

Exclusion. The first and basic measure to control abacá is prevention of the introduction of the virus into the plantation or area. This can be done only by careful selection of disease-free suckers from disease-free stools in a multiplication plot or seed bank. Such plants or seed banks must be constantly inspected by someone

thoroughly familiar with the disease at intervals of not more than one month, preferably every three weeks (Reinking, 1949; Ocfemia, 1947, 1950). In the absence of a seed bank, two measures should be instituted: selection of planting stock from an established plantation that has been surveyed and is known to be virus-free for at least six months and establishment, cooperatively if possible, of a seed bank which will be properly controlled (Ocfemia, 1950; Reinking, 1950).

If a new area is being planted, it should be quarantined, and only certified disease-free seeds should be taken into the area (Ocfemia, 1949, 1950; Reinking, 1950). If the clean planting material is to remain virus-free, other sources of the virus must also be eliminated. Since grass mosaic virus is likely to be present in the area, a weed control program must be instituted before the abacá is planted. Young suckers are colonized by aphids and the setting of planting stocks in a weedy area defeats the use of disease-free stocks (Reinking, 1949). The weed control program will be easier if started before setting and, in any case, must be continued during growth of the abacá until a canopy forms that prevents weed growth.

Eradication. As soon as mosaic is seen in a stalk of abacá, all stalks and corms connected with it should be destroyed. The most successful way of doing this is to dig up the hill, carefully separate the entire clump containing the diseased stalk, cut the clump into sections, and scorch the sections so no aphids or leaf hoppers will feed on them. Since this method is costly in terms of labor, a less expensive method is to cut all stalks, cut a cup-shaped hollow in the stumps, and treat the stalks with some form of 2,4-D or any other approved weed killer. Sufficient 2,4-D should be applied to kill the eyes attached to the stalks. The stalks should be covered with a healthy abacá leaf to prevent evaporation of the weed killer. Since in this method it is nearly impossible to determine the extent to which the clump is affected, the entire hill must be destroyed. The destruction of the entire hill is essential in plantings of less than 12 months of age, but in older stands this would open the canopy, allowing the development of weeds and aphids. Since the growth of weeds and aphids may result in more virus spread and since replants require some time to produce marketable stalks, it is desirable that only the diseased stalks and the suckers attached to them be removed in the older stands. This is known as "partial removal." If only a portion of the hill is destroyed, the hill must be revisited every 10 days for two to three months to be sure all diseased portions have been destroyed. Any new evidences of disease call for further and immediate treatment (Calinisan, 1934; Reinking, 1949; Ocfemia, 1950).

In deciding whether to use partial or complete removal of a hill, the relation of age of plant to separation of clumps should be considered (Epiphytology).

Mature stems or stems containing marketable fiber should be stripped or tuxied immediately and the debris scorched.

Plantations with mosaic or those in mosaic-infested areas should be visited every three to four weeks and thoroughly surveyed for diseased plants. Removal of the diseased plants should be effected immediately.

Just as any diseased abacá plant must be removed, so must any other virus-containing plant. The easiest way to do this is not to plant any susceptible plants and to completely control weeds. Grasses especially must be controlled carefully because of the ease with which grass mosaic virus is transmitted to abacá (Reinking, 1949; Ocfemia, 1950).

Protection. Protection of the abacá plantation against mosaic can be insured by two measures, both directed toward the vectors of the virus. Since the vectors, especially the aphids, develop primarily on weeds, grasses, and crops planted in the plantation, the elimination of such crops would greatly reduce spread of mosaic by a proportionate reduction in the vectors. The complete control of weeds is most beneficial because of the effect on the insect population. If weeds are allowed to grow, the aphids develop on them and then when the weed growth declines, the aphids are moved to the abacá and transmit the virus (Reinking, 1949; Ocfemia, 1949, 1950).

The practice of interplanting corn with abacá must be abandoned. Corn is probably the most favored food plant of the corn aphid. The aphids increase on the corn and when the corn matures or is harvested, the aphids are shifted to the abacá. They may pick up the virus from the corn, but the greatest danger comes from the aphids feeding on diseased abacá and then shifting to healthy abacá. The aphids that do not prefer abacá as food do not produce well, and the ants shift them from plant to plant (Ocfemia, 1949).

The second protective measure is the application of insecticide on the infected abacá plant that is to be removed, on all plants adjacent to it, and on the intervening soil, weeds, and other plants. This application of insecticide must be made before the plant is cut, or aphids will be shaken off and will get to the healthy abacá plants. The insecticides recommended are Foliafume, Medol oil, or a soap-kerosene emulsion. All plant parts, especially the suckers, must be thoroughly sprayed (Reinking, 1949; Agati and Castillo, 1951; Agati, 1953).

Immunization. One of the main preventive measures in the control of mosaic or any other plant disease is the maintenance of the plants in a healthy condition. Plants should never be overstripped. Overstripping not only weakens the plants but also makes them more susceptible to aphid feeding, thus markedly increasing the problem of weed control and the consequent increase in aphids (Reinking, 1949; Ocfemia, 1950).

The maintenance of proper cultural practices will also further the control of mosaic through control of weeds, control of aphids, and better growth of the abacá.

There are no known commercial varieties of abacá that are resistant to mosaic. All commercial varieties tested so far have proved susceptible. There are, however, three sources of resistance that may be introduced into abacá varieties. The wild Musas, pacol, canton, and *Musa lolodensis,* have been shown to be highly resistant to mosaic. Pacol has been readily crossed with commercial varieties. Canton appears to cross with the commercial varieties if used as the female parent. *Musa lolodensis* has the same chromosome number as abacá and should therefore cross with the commercial varieties. Underway are at least two active programs attempting by the use of these sources of resistance to develop resistant varieties possessing high fiber quality (Agati, 1953; Cruz, 1953).

The above program needs one further step at present. The resistant varieties have been assumed to be resistant on the basis of their failure to develop symptoms following inoculation. The resistant sources, F_1's, and backcrosses should be subcultured to healthy abacá following inoculation to assure that they are truly resistant and not masked carriers.

Finally, it should be mentioned again that control of mosaic in abacá will depend on full cooperation between the growers, the Control Unit, the Extension people, and the research group. The success of the last three depends on the cooperation and support of the first.

BIBLIOGRAPHY

ANON. 1949. The mosaic disease of abacá and its control. Mimeographed Leaflet, Plant Path. Sec., Plant Pest and Disease Control Div., Bureau of Plant Industry, Manila, Philippines.

ANON. 1953. Technical Personnel Training School and Abacá Growers Mosaic Conference Proceedings. Plant Industry Digest (Philippines) **16** (10): 54–78.

AGATI, JULIAN A. Annual report, Abacá Mosaic Control Unit. Bureau of Plant Industry, DANR., Philippines: 1–29. Mimeographed.

AGATI, JULIAN A., AND BERNARDO S. CASTILLO. 1951. How to control abacá mosaic. Pamphlet No. 1: 1–3. Abacá Mosaic Control Unit, Davao City. Mimeographed.

CALINISAN, M. R. 1934. Notes on a suspected "mosaic" of abacá in the Philippines. Philippine Jour. Agric. **5**: 255–258.

CALINISAN, MELANIO R. 1938a. Transmission experiments of abacá mosaic. (Progress report No. 1). Philippine Jour. Agric. **9**: 309–313.

CALINISAN, MELANIO R. 1938b. The three destructive diseases of abacá in Davao (bunchy top, mosaic and the vascular disease) and their control. Philippine Jour. Agric. **9**: 329–333.

CALINISAN, MELANIO R. 1939. A comprehensive study on symptoms of abacá mosaic. Philippine Jour. Agric. **10**: 121–130.

CANN, H. J. 1952. Bunchy top virus of bananas "at all time low" in N.S.W. Agric. Gaz. N.S.W. **63**: 73–76.

CASTILLO, BERNARDO S., AND JULIAN A. AGATI. 1950. Using weedicides in eradicating mosaic infested abacá plants. Philippine Jour. Agric. **15**: 175–185.

CASTILLO, BERNARDO S. 1952. Transmission studies of banana mosaic in the Philippines. Plant Industry Digest (Philippines) **15** (10): 39.

CASTILLO, B. S. 1953. Chart of hosts and vectors of abacá mosaic. Exhibit at Abacá Mosaic Control Schools, Davao City, Sept. 8–11.

CELINO, MARTIN S. 1940. Experimental transmission of the mosaic of abacá or Manila hemp (*Musa textilis* Née). Philippine Agriculturist **29**: 379–403.

CELINO, M. S., AND G. O. OCFEMIA. 1941. Two additional insect vectors of mosaic of abacá, or Manila hemp plant, and transmission of its virus to corn. Philippine Agriculturist **30**: 70–78.

CRUZ, EUGENIO E. 1951. Abacá culture in the Philippines (revised). Plant Industry Digest (Philippines) **14** (6): 7–20.

CRUZ, EUGENIO E. 1953. Research program of the Davao Abacá Experiment Station, and seedling banks, Bureau of Plant Industry. Plant Industry Digest (Philippines) **16** (10): 90–93.

HOLMES, F. O. 1939. Handbook of phytopathogenic viruses. vii + 221 p. Minneapolis, Minn.: Burgess Publishing Company.

HOLMES, F. O. 1948. The filterable viruses. Bergey's manual of determinative bacteriology. 6th ed. Baltimore: The Williams & Wilkins Company.

JULIANO, JORGE P. 1951. A study of the mosaic disease of abacá, or Manila hemp plant (*Musa textilis* Née), with special reference to sources of inoculum and possible transmission of the virus by mechanical means. Philippine Agriculturist **34**: 125–132.

KENT, G. C. 1953a. The symptoms and host range of abacá mosaic. Plant Industry Digest (Philippines) **16** (10): 27–30.

KENT, G. C. 1953b. The fundamentals of virus diseases of plants. Plant Industry Digest (Philippines) **16** (10): 20–26.

LAWAS, O. M., AND W. L. FERNANDEZ. 1949. A study of the transmission of the corn mosaic and some of the physical properties of its virus. Philippine Agriculturist **32**: 231–238.

OCFEMIA, G. O. 1937. The abacá disease situation in Davao. Philippine Agriculturist **26**: 229–236.

OCFEMIA, G. O. 1949. The rapid dissemination of the mosaic disease of abacá, or Manila hemp plant (*Musa textilis* Née), in the field. Philippine Agriculturist **33**: 142–144.

OCFEMIA, G. O. 1950. The control of abacá mosaic. College of Agriculture Biweekly Bull. **14** (15): 1–2.

OCFEMIA, G. O. 1953a. Transmission of abacá mosaic. Plant Industry Digest (Philippines) **16** (10): 30–33.

OCFEMIA, G. O. 1953b. Symptoms of virus-diseased plants. Plant Industry Digest (Philippines) **16** (10): 26–27.

OCFEMIA, G. O., AND MARTIN S. CELINO. 1938. Transmission of abacá mosaic. Philippine Agriculturist **27**: 593–598.

OCFEMIA, G. O., MARTIN S. CELINO, AND FELICIANO G. GARCIA. 1947. Further studies on transmission of bunchy top and mosaic of abacá (Manila hemp plant), separation of the two diseases, and mechanics of inoculation by *Pentalonia nigronervosa* Coquerel. Philippine Agriculturist **31**: 87–97.

OCFEMIA, G. O., ISIDRO S. MACASPAC, AND FENG YUAN HSIEH. 1941. Experimental transmission of the mosaic of *Canna indica*. Philippine Agriculturist **30**: 357–370.

REINKING, OTTO A. 1945. Preliminary studies of abacá diseases in Panama. Plant Disease Reporter **29**: 390–393.

REINKING, OTTO A. 1949. Abacá disease studies: Davao, Philippine Islands. Plant Disease Reporter **33**: 456–462.

REINKING, OTTO A. 1950a. Abacá mosaic in the Davao and Cotabato Provinces. Disease situation critical and needs immediate attention. Report to Bureau of Plant Industry, July 29.

REINKING, OTTO A. 1950b. Abacá mosaic in Davao and Cotabato Provinces. Report, Aug. 25.

REINKING, OTTO A. 1951a. Progress report on abacá mosaic disease control. Analyses of control campaign with suggested changes. Mimeographed report, Mar. 5.

REINKING, OTTO A. 1951b. Second progress report of the abacá mosaic disease control campaign: 1–31. *Appendix I & II.* Mimeographed, Aug. 1.

REINKING, OTTO A. 1952a. Third progress report on the abacá mosaic disease control campaign: 1–39. Mimeographed, Mar. 6.

REINKING, OTTO A. 1952b. Fourth progress report on the abacá mosaic disease control campaign: 1–32. Mimeographed, May 7.

SPENCER, J. E. 1953. The abacá plant and its fiber, Manila hemp. Economic Bot. 7: 195–213.

TABLE 1

Vector relations in abacá mosaic

PRIMARY SOURCE	INTERMEDIATE SOURCE	HOST	APHIS GOSSYPII	APHIS MAIDIS	RHOPALOSIPHUM NYMPHAEAE	RHOPALOSIPHUM PRUNIFOLIAE	PROUTISTA MOESTA
Abacá	None	Abacá	+		+	+	+
Canna indica	None	Abacá	+	+	−		
Corn	None	Abacá	−	+			
Cowpea	None	Abacá		+			
Panicum colonum	None	Abacá	+	+			
Arrowroot	None	Abacá	+	+			
Seedy *Musa* spp.	None	Abacá	+	+			
Abacá	None	Corn		+			
Corn	None	Corn	+				
Culapé	None	Corn	+				
Canna indica	None	*C. edulis*	+				
Abacá	None	*C. edulis*	−		−		
Abacá	None	*C. indica*	+		+		
Culapé	None	Abacá		−			
Culapé	*C. indica*	Abacá		+			
Crabgrass	None	Abacá	−	−			
Crabgrass	Corn	Abacá	+	+			
Cogon	None	Abacá		−			
Cogon	Corn	Abacá		+			
Sugar cane	None	Abacá		−			
Sugar cane	Corn	Abacá		+			
Panicum colonum	Corn	Abacá		+			
Abacá	None	Banana	−		−		
Culapé	None	Abacá		−			

\+ = Transmission obtained.
− = No transmission obtained.
Blank = No test recorded.

THE INFLUENCE OF SPRINKLER IRRIGATION ON THE YIELD OF CORN GROWN FROM MARCH TO JUNE [1]

EDILBERTO A. UICHANCO

Corn plants grown in fertilized, well-drained Lipa clay loam and irrigated with a total of 46.71 hectare-centimeters of water gave a greater yield of shelled corn than those which were irrigated with relatively less. In spite of the fairly good yield, the high labor cost and miscellaneous charges involved in the sprinkler method of irrigation made the production of corn during the driest part of the year uneconomical. The results suggest that less expensive methods of irrigation at higher rates of application than those used in this study should be tried to justify dry-season corn culture.

Corn is ordinarily grown only two times a year in the Philippines. In Los Baños, the wet-season crop is planted in May and harvested in August; the dry-season crop is planted in November and harvested in February of the following year. The yield of the dry-season culture is much lower than that of the wet-season culture. One of the major causes of the difference in yield may be soil moisture. Unfortunately, no study has been performed along this phase of corn culture in the Philippines.

Widtsoe (1916) found that maximum corn yields of nearly 100 bushels of grain an acre (107.4 cavans per hectare) were produced in Central Utah Station with 25 inches (63.5 centimeters) of irrigation water. He also got excellent yields with only 10 to 15 inches (25.4 to 35.1 centimeters) and concluded that with favorable soil and in a climate such as prevails in Cache Valley, Utah, 12 to 15 inches (30.4 to 38.1 centimeters) of water is satisfactory for corn. Pittman and Stewart (1930) showed that under the conditions of the Utah Central Experiment Station Farm, corn yield increases with increase in irrigation water up to about twenty inches (50.8 centimeters); that the yields change little as the water is increased from 20 to 30 inches (50.8 to 76.2 centimeters); and that above these water levels the yields decrease. With an adequate supply of water on fertile soil, the corn crop will yield from 60 to 80 bushels of grain an acre (64.4 to 85.9 cavans per hectare).

The results of a sprinkler irrigation experiment on corn conducted at Fayetteville, Arkansas, indicated that respectable corn yields can be obtained even in dry seasons by the use of supplemental irrigation (Brown and Benedict, 1953). Irrigation water was applied when the available soil moisture had decreased to 50 per cent.

---

[1] Central Experiment Station Contribution No. 1757. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture. Prepared in the Department of Agricultural Engineering under the direction of Professor Alejandro B. Catambay.

Two inches of water was applied to bring the soil moisture in the root zone to field capacity, or to 100 per cent available soil moisture level. A total of 10 inches of irrigation water was used. The corn needed irrigating approximately every 15 to 20 days, even though a total of 11.08 inches of rain fell during the growing season. The yield of corn in the nonirrigated plots was 17 bushels an acre and in the irrigated plots, 70 bushels. The authors concluded that soil moisture was the limiting factor to the yield.

Thorne and Peterson (1949) enumerated the following advantages of sprinkler irrigation: (a) even distribution of water; (b) low labor requirement and cost of land preparation; (c) adaptation to hilly and unlevel land; (d) adaptation to some very porous soil types; (e) ability to irrigate even rolling land without erosion; (f) less total water and smaller heads required than with other methods; (g) washing of plant foliage; and (h) provision for distribution of soluble fertilizer with the water. They also gave the following disadvantages of the method: (a) rather high initial cost; (b) cost of power to provide pressure must be added to irrigation charges; (c) considerable labor involved; (d) much water may be lost due to evaporation and wind [Christiansen (1942) found that such losses were nominal and seldom exceeded 2 per cent of the water applied]; (e) water falling on the soil surface may break up the aggregates, decreasing infiltration rates and causing severe crusting, particularly when the plants are small; (f) in many crops there may be a removal of spray materials and some interference with pollination; and (g) moistening of the foliage may favor some diseases.

The present work was conducted in the Central Experiment Station and in the Department of Agricultural Engineering from February, 1953, to February, 1954, to determine the best rate at which corn grown from March to June may be irrigated by the overhead sprinkler method. The labor requirement and the cost of producing the crop were also calculated.

MATERIALS AND PROCEDURE

Preparation of the land. From February 15 to March 11, the 0.16-hectare experimental field was plowed twice with a 2-26-inch plow mounted on a Farmall-H tractor. Each plowing was immediately followed by harrowing with a 28-16-inch double gang disc harrow to pulverize the soil thoroughly and to level the field.

The experimental plot is located on the right side of the Central Experiment Station road west of the railroad tracks. The field had previously been planted to corn. The soil is of the Lipa clay loam type. Galvez and Pagador (1951) reported that the soil in this field has a water-holding capacity of 79.01 per cent, organic matter content of 5.86 per cent, total nitrogen of 0.23 per cent, P_2O_5 of 0.09 per cent, K_2O of 0.16 per cent, and pH in 0.1 normal KCl of 5.40. The average yields of this lot under mechanized and fertilized cul-

tures are 45 cavans of shelled corn per hectare in the wet season and 27 cavans in the dry season.

Planting and application of fertilizer. College Yellow Flint variety of corn was planted on March 11 with a mounted two-row HM-220 planter. The distance between rows was 106 centimeters, and between hills, 71 centimeters. Two to four seeds were dropped in each hill.

Fertilizing was done simultaneously with planting. Ammonium phosphate fertilizer (16-20-0) was applied at the rate of 200 kilograms to a hectare.

Field layout. The experimental field was divided into five blocks, representing five replications, laid side by side. Each block was composed of four plots, representing the treatments. Plot treatments were made at random. Each plot had two rows 40 meters long. Guard rows between plots were not considered necessary because of the small area that the irrigation water penetrated.

Irrigation. A Dobbins power sprayer of 250-gallon tank capacity was used to apply the irrigation water. The nozzles of the sprayer were changed to produce an ample, even, and narrow stream of water which was directed on the ridge of the furrows, right at the base of the plants.

The sprinkler was calibrated at 17.069 liters to a plot for each application.[2] Rate 0 (control) received no water. Rate I received two applications every day; rate II, four applications; and rate III, six applications. Blocks I to IV were irrigated in the afternoons, from two to four o'clock, and block V from eight to nine o'clock the following morning. This was done because the water tank did not contain enough water to irrigate the whole field.

Irrigation continued from April 7 to May 3. The operation was stopped when the plants were about ninety-five centimeters tall. The tractor and sprinkler clearance had become so small as to cause the breaking of stalks and, possibly, the disruption of pollination. Rains at this point had become more frequent and more intense.

Cultivation. The plants were cultivated on April 20, when they were already about sixty centimeters tall, with a McCormick-Deering HM-238 two-row cultivator with sweep blades.

Harvesting. The crop was harvested on June 30. The ears were hand-picked and placed in sacks and were transported to the Department of Agricultural Engineering for drying, husking, shelling, and weighing.

RESULTS AND DISCUSSION

Stand of crop. The irrigated plants generally had a faster rate of growth than the unirrigated. The intensity of vegetative growth

[2] The sprinkler was passed over each plot at a constant speed and with a constant flow of water from the nozzles during every application. The tractor was run on second gear and the throttle maintained at a permanent position during the operation.

increased with the increased application of water. The height of the plants in the unirrigated plots ranged from .9 to 1.1 meters; that in the irrigated plots, from 1.3 to 1.8 meters.

The field was devoid of weeds at the start of the experiment. As the rains became more frequent, the weeds began to show up. The plants at this time were already tall and were approaching maturity. Common weeds found were *Calopogonium muconoides* Desv., *Ipomoea triloba* L., *Roetboellia exaltata* L. (aguingay), and *Amaranthus spinosus* L. The only pest observed attacking the crop was corn-ear worm, *Heliothis armigera* Hübner.

Irrigation. The soil moisture at the start of the experiment was 2.8 per cent on the oven-dry basis.[3] When irrigation was first applied, the plants were showing signs of wilting. Rate I treatment had an average depth of penetration of 0.51 centimeter taken five minutes after application; rate II had 0.98 centimeter; and rate III had 1.53 centimeters. A total of 43.73 centimeters of rain fell during the growing season (table 1). The corn in the control plot was supplied with a total of 43.73 hectare-centimeters of water during its growing period; the plants in rate I, 44.72 hectare-centimeters; those in rate II, 45.71 hectare-centimeters; and those in rate III, 46.71 hectare-centimeters. Irrigation was made more effective by the application of water directly along the base of the plants, so as to wet only the root zone.

Yield. The yields of shelled corn in the irrigated plots were high, considering that the crop was off-season and that, except for the period from tasseling up to maturity, it was grown during the driest months of the year (table 2). The relation of yield to the amount of irrigation water added was positive, with a coefficient of regression (b) of 6.35 and a standard error (s_b) of 0.54. In testing for the null hypothesis ($B = 0$), a t-value of 11.85 was computed, which was greater than the tabular t-value at the 1 per cent level. The null hypothesis was therefore rejected. The amount of irrigation water positively affected the yield.

Cost of production. All computations used in determining the cost of production of the crop were based on current labor rates and cost of supplies.

Charges for the use of machinery and implements (table 3) were determined using the following formulae by Catambay (1950):

$$\text{Depreciation} = \frac{0.97C}{y \times m \times 8} \quad \text{(per hour)}$$

$$\text{Interest} = \frac{0.97C \times r'}{2 \times m \times 8} \quad \text{(per hour)}$$

$$\text{Housing and repairs} = \frac{C \times r''}{m \times 8} \quad \text{(per hour)}$$

[3] Determined in the Department of Soils Laboratory.

where

C = cost of equipment
y = estimated life in years
m = estimated maximum number of days the equipment is used in one year
r' = rate of interest on investment (7 per cent)
r'' = rate of charge on first cost of equipment (3 per cent).

The cost of production in the irrigated plots was considerably higher than in the unirrigated plots because of the high labor requirement, fuel costs, and miscellaneous charges for operating the sprinkler (table 4). The method of irrigation employed in this study was found to be expensive.

The total cost of production per hectare for the unirrigated culture was ₱169.59, and that for the irrigated culture was ₱478.83 (table 5).

The cost of producing a cavan of shelled corn was ₱11.34 for the control plot, ₱20.34 for rate I plot, ₱16.65 for rate II plot, and ₱13.92 for rate III plot. With the current price of ₱10.00 a cavan of shelled corn, the unirrigated plot would have a net loss of ₱19.99 per hectare; rate I plot, ₱243.31; rate II plot, ₱191.11; and rate III plot, ₱134.71.

These results show that corn can be grown during the driest part of the year with a fairly good yield, but a method of irrigation less expensive than that used in this study should be employed to justify its production.

LITERATURE CITED

BROWN, D. A., AND R. H. BENEDICT. 1953. Increasing corn yields through supplemental irrigation. Arkansas Farm Research 2: 1.

CATAMBAY, A. B. 1950. Mechanized corn culture. Agric. Engin. Jour. 1: 17–19, 23, 36–38.

CHRISTIANSEN, J. E. 1942. Irrigation by sprinkling. Calif. Exper. Sta. Bull. 670. *Cited in* Thorne, D. W., and H. B. Peterson. 1949. Irrigated soils, their fertility and management. ix + 288 p. Philadelphia and Toronto: Blakiston Co.

GALVEZ, N. L., AND F. R. PAGADOR. 1951. Some physical and chemical properties of forest and cultivated soils. Philippine Agriculturist 35: 41–46.

PITTMAN, D. W., AND GEORGE STEWART. 1930. Twenty-eight years of irrigation experiments near Logan, Utah. Utah Agric. Exper. Sta. Bull. 219. *Cited in* Israelsen, W. O. 1950. Irrigation principles and practices. 2nd ed., xii + 405 p. New York: J. Wiley and Sons, Inc.

THORNE, D. W., AND H. B. PETERSON. 1949. Irrigated soils, their fertility and management. ix + 288 p. Philadelphia and Toronto: Blakiston Co.

WIDTSOE, J. A. 1916. The production of dry matter with different quantities of irrigation water. Utah Agric. Exper. Sta. Bull. 116. *Cited in* Israelsen, W. O. 1950. Irrigation principles and practices. 2nd ed., xii + 405 p. New York: J. Wiley and Sons, Inc.

TABLE 1

Meteorological observations during the growing period of the corn plants [a]

PERIOD OF OBSERVATION	TEMPERATURE		RELATIVE HUMIDITY	RAINFALL		CLOUDINESS
	Minimum	Maximum		Total	Distribution	
1953	*°C.*	*°C.*	*per cent*	*mm.*	*days*	
March	24.72	31.94	69.55	17.1	7	5.93
April	26.06	33.26	67.40	3.8	2	4.16
May	25.51	33.45	76.57	158.2	14	6.30
June	25.12	30.65	50.96	258.2	23	5.08
Total				437.3	46	
Mean	25.35	32.33	66.12	109.32	11.5	5.37

[a] Data were obtained from the Weather Station of the UP College of Agriculture.

TABLE 2

The influence of three rates of sprinkler irrigation on the yield of corn grown from March to June, 1953

TREATMENT	YIELD		IRRIGATION WATER [a]
	Plot average	Average per hectare	
	kilos	*cavans*	*ha./cm.*
0	7.00	14.96	—
I	10.93	23.54	0.9921
II	13.46	28.76	1.9843
III	16.10	34.40	2.9764

[a] Precipitation not included.

TABLE 3

Charges for the use of machinery and implements

KIND OF IMPLEMENT	COST	MAXIMUM NO. OF DAYS USED IN A YEAR	ESTIMATED LIFE IN YEARS	IRRIGATED PLOTS				UNIRRIGATED PLOTS			
				Hours used	Depreciation	Interest	Housing and repairs	Hours used	Depreciation	Interest	Housing and repairs
	pesos				*pesos*	*pesos*	*pesos*		*pesos*	*pesos*	*pesos*
Farmall-H tractor .	4,775	140	8	123.98	64.10	17.98	15.85	22.73	11.75	3.30	2.91
Ferguson tractor ..	3,405	140	8	3.60	1.33	0.37	0.33	3.60	1.33	0.37	0.33
Tractor plows	1,017	100	12	6.40	0.66	0.28	0.24	6.40	0.66	0.28	0.24
Disc harrows	700	100	12	2.60	0.18	0.08	0.07	2.60	0.18	0.08	0.07
Spike-tooth harrow.	180	100	12	2.60	0.05	0.02	0.02	2.60	0.05	0.02	0.02
Planter	952	60	15	1.90	0.24	0.13	0.11	1.90	0.24	0.13	0.11
Cultivator	642	100	10	4.00	0.31	0.11	0.10	4.00	0.31	0.11	0.10
Sprinkler	2,418	100	10	101.25	28.65	10.43	8.20	—	—	—	—
Corn picker	3,355	100	10	4.50	1.83	0.64	0.57	4.50	1.83	0.64	0.57
All-purpose trucks .	1,200	100	10	3.60	0.79	0.28	0.08	3.60	0.79	0.28	0.24
Corn sheller	586	100	10	3.33	0.24	0.08	0.07	1.76	0.13	0.04	0.04
Winnower	100	100	10	2.00	0.02	0.01	0.00	1.00	0.01	0.005	0.00
			Total	98.40	30.41	25.64			17.28	5.26	4.63
			Grand total ...		154.45					27.17	

TABLE 4

Labor requirement and cost per hectare of irrigated and unirrigated cultures of corn grown from March to June, 1953

OPERATION	IRRIGATED CULTURE		UNIRRIGATED CULTURE	
	Man hours	Labor cost [a]	Man hours	Labor cost [a]
		pesos		*pesos*
Land preparation:				
Two plowings	6.40	3.60	6.40	3.60
Two harrowings	2.60	1.46	2.60	1.46
Planting [b]	1.90	2.02	1.90	2.02
Cultivation	4.00	2.25	4.00	2.25
Irrigation [c]	101.25	56.95	—	—
Harvesting [d]	4.50	4.77	4.50	4.77
Hauling [e]	3.60	5.62	3.60	5.62
Shelling [f]	3.33	8.32	1.76	4.84
Cleaning [e]	2.00	3.00	1.00	1.50
Total	129.58	87.99	25.76	25.46

[a] The tractor operator received ₱4.50 for one 8-hour day. All other laborers received ₱4.00.

[b] Two men were required for the operation.

[c] Irrigation was based on one trip of the sprinkler for every treatment. Only the rate of flow of water was changed to correspond to requirement.

[d] E. A. Pili, "The Performance of the Mounted and the Drawn Corn Pickers." (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, 1953. Unpublished.)

[e] Three men were required for the operation.

[f] Five men were required for the operation.

TABLE 5

Cost of producing corn in irrigated and unirrigated plots from March to June, 1953

COST	COST PER HECTARE	
	Irrigated [a]	*Unirrigated*
	pesos	*pesos*
Labor cost	87.99	25.36
Supplies	189.94	75.55
Seed cost, 5 gantas at ₱0.72 a ganta	3.60	3.60
Land rent, 6 months at ₱70.00 per hectare a year	35.00	35.00
Charges for the use of machinery and implements	154.45	27.17
Interest on average working capital at 7% per annum	7.85	2.91
Total cost of production per hectare	478.83	169.59
Cost of producing a cavan of shelled corn	13.92	11.34

[a] Based on the lots receiving the heaviest irrigation.

CHEMICAL COMPOSITION OF CERTAIN LIVESTOCK FEEDS [1]

L. A. Ynalvez, Lolita Austria, Epifania Cruz, and J. K. Loosli [2]

Fifty-six livestock feeds were chemically analyzed for moisture, crude protein, ether extract, crude fiber, nitrogen-free extract, ash, calcium, and phosphorus.

Adriano [3] analyzed the chemical composition of many of the livestock feeds common in the Philippines and studied the changes in composition of guinea grass with advancing maturity. More recent data on certain feeds have been published by the Bureau of Animal Industry.[4] Analyses for such minerals as calcium, phosphorus, iron, or the trace elements have not been reported in the literature, however.

This paper reports the first part of a systematic survey to determine the composition and feeding value of Philippine livestock feeds.

The samples were carefully collected to prevent contamination and thus avoid erroneous values. They were dried either under infrared lamps or in the sun; in no case were they exposed to rain. Some of the samples analyzed were composites of 10 to 20 separate samples of forages collected during a digestion experiment. Since the stage of maturity is known to markedly influence the chemical composition and nutritive value of forage crops, an attempt was made to describe the maturity of the grasses. The roughages analyzed were from fields that had not been fertilized.

Analyses of the forages on a fresh basis and of the concentrates on an air-dry basis are summarized in table 1.

The relative values of various feeds are much easier to compare when the analyses are expressed on a moisture-free basis, as shown in table 2.

A comparison of the data with the earlier studies cited and with analyses from other countries [5] reveals only minor variations among the same kinds of feeds. Legumes grown in the Philippines appear to be fully as high in protein and calcium as those grown in the United States and in Europe. Likewise, decreases in protein

---

[1] Central Experiment Station Contribution No. 1758.

[2] The authors gratefully acknowledge the assistance of Dr. Valente Villegas who collected some of the samples and of Mr. S. E. Claud who dried and prepared many of the samples for analyses.

[3] F. T. Adriano, *Philippine Agriculturist*, 18, 199 (1929).

[4] D. Y. Odejar and L. R. Masankay-Arenas, *Philippine Jour. Anim. Indus.*, 12, 29 (1951); 10, 371 (1949).

[5] F. B. Morrison, "Feeds and Feeding," Morrison Publishing Company, New York, 1951, 1207 pp.

and increases in fiber with advancing maturity of cogon and para grass follow the same trends reported elsewhere. It is evident that these changes warrant extensive study as part of the effort to find forages that are most useful for livestock in the various areas of the Philippines. Likewise, the influence of fertilizers and of management practices upon the composition of livestock feeds should be studied.

TABLE 1

Chemical composition of livestock feeds

FEEDS	PERCENTAGE COMPOSITION						NO. OF ANALYSES
	Dry matter	Crude protein	Ether extract	Crude fiber	N-free extract	Ash	
Concentrates and roots:							
Cassava roots	36.7	0.9	0.8	0.5	33.3	1.2	1
Coconut meat (fresh)	51.2	5.0	33.0	2.2	9.5	1.5	1
Coconut residue	90.8	6.1	5.0	34.7	24.3	1.3	1
Copra meal	93.0	21.0	7.8	8.8	48.4	7.0	2
Corn gluten feed	91.6	22.2	3.1	6.6	58.7	1.0	1
Corn, Yellow Flint	82.9	9.0	2.4	2.3	1.8	1.6	1
Fish meal	85.0	56.0	3.3	0.5	19.0	6.2	1
Ipil-ipil seeds	86.8	26.3	6.9	11.2	38.6	3.8	1
Molasses cane	77.4	1.1	1.3	0	67.1	7.9	2
Poñgapong (*Amorphophallus campanulatus* [Roxb] Blm.)	16.3	1.4	0.2	0.8	13.0	0.9	1
Rice bran, fine	88.0	11.4	10.5	12.3	43.1	12.0	2
Susong papang (meat and shell)	29.3	3.5	0.2	0.3	2.9	22.4	1
Totong (rice and coconut)	78.1	5.7	2.4	0.2	69.3	0.5	1
Forages:							
Aguingay (*Rottboellia exaltata* Linn.)	15.0	1.1	0.5	5.2	5.5	2.6	1
Alabang X (*Andropogon nodosus* [Willem] Nash.) before heading	25.2	1.4	0.9	9.8	9.9	3.2	2
" " " while seeds are forming	21.6	1.1	1.5	8.8	7.9	2.3	1
" " " leaves	36.6	3.1	1.2	12.8	14.9	4.6	1
" " " stems	36.5	0.9	0.3	17.8	14.5	3.0	1
Alfalfa before blooming	18.5	4.5	0.8	4.7	6.6	1.9	1
Asis (*Ficus ulmifolia* Lam.)	27.5	4.7	0.8	5.2	12.5	4.3	1
Bamboo (*Bambusa spinosa* Roxb.)	35.2	4.8	0.3	10.8	12.1	7.2	1
Banig (*Panicum flavidum* Retz)	18.7	2.0	0.5	5.4	7.1	3.7	1
Barit (*Leersia hexandra* Sw)	44.2	3.2	1.0	13.8	19.4	6.8	1
Batao (*Dolichos lablab* Linn.)	17.0	3.6	0.2	6.1	5.0	2.1	1
Bulang (*Panicum auritum* Presl)	18.6	1.9	0.4	5.4	8.4	2.5	1
Bungalon (*Echinochloa stagnina* Beauv.)	23.7	1.3	0.3	8.0	11.6	2.5	1
Calopogonium mucunoides in flower	31.6	4.3	1.8	9.4	13.6	2.6	1

TABLE 1 (continued)

FEEDS	PERCENTAGE COMPOSITION						NO. OF ANALYSES
	Dry matter	Crude protein	Ether extract	Crude fiber	N-free extract	Ash	
Camote-camotehan (*Ipomoea triloba* Linn. and *Meramia utifolia*)	13.8	2.3	0.2	4.6	4.5	2.2	1
Carirawraw (*Digitaria pruriens* [Trin] Busse)	18.5	1.7	0.6	6.2	7.9	2.1	1
Casadores leaves (*Synedrella nodiflora* [Linn.] Gaertn.)	17.9	3.3	0.3	4.1	6.4	3.8	1
Caturay leaves (*Sesbania grandiflora* Pers)	20.9	5.3	1.0	3.8	9.1	1.7	1
Centrosema pubescens	20.5	3.8	1.2	7.8	5.9	1.8	2
Cogon (*Imperata cylindrica* [Linn.] Beauv.)							
10 days (30 cm. tall)	23.3	2.3	0.5	7.7	10.8	2.0	1
20 days (45 cm. tall)	22.9	2.4	0.4	9.0	9.2	1.9	1
90 days (120 cm. tall)	34.7	1.9	1.0	13.3	16.0	2.5	3
Corn fodder	20.9	1.1	0.3	8.2	8.0	3.3	1
Corn silage, Yellow Flint, few ears	26.0	1.5	1.0	8.6	12.6	2.3	1
Culapé (*Paspalum conjugatum* Berg.)	17.5	1.9	0.4	5.6	7.4	2.2	2
Guatemala (*Tripsacum laxum* Nash), 120 cm. tall	17.7	1.5	0.2	6.6	7.5	1.9	1
180 cm. tall	22.0	1.3	0.3	8.0	10.4	2.0	2
Guinea grass (*Panicum maximum* Jacq.) no flowers	18.9	1.3	0.2	7.5	7.1	2.8	1
Gutad (*Echinochloa colonum* [L.] Link)	16.7	1.6	0.5	4.9	7.5	2.2	1
Ipil-ipil leaves (*Leucaena glauca* [Linn.] Benth.)	29.2	8.0	1.6	5.4	12.0	2.2	1
Molasses grass (*Melinis minutiflora* Beauv.)	17.4	1.2	0.2	7.2	7.1	1.7	1
Mungo soilage	24.8	2.9	0.6	5.7	13.1	2.5	2
Mutha (*Cyperus iria* Linn.)	17.9	1.9	0.5	4.6	8.1	2.8	1
Natal grass (*Rhynchelytrum roseum* [Ness] Stapf and Hubb)	31.5	1.8	0.6	12.9	13.6	2.8	1
Para grass (*Panicum purpurascens* Raddi) 40 cm. tall	24.1	3.0	0.8	7.1	10.1	3.1	2
90 cm. tall, not in flower	22.3	2.0	0.5	7.5	9.5	2.8	1
110 cm. tall, dry leaves	20.5	1.8	0.3	6.5	9.7	2.2	1
Penisetum sitosum	24.1	1.4	0.4	9.7	10.1	2.5	1
Pulang puwet (*Echinochloa colonum* [L.] Link)	8.6	0.8	0.1	3.1	3.0	1.6	1
Rice straw	72.7	3.1	1.9	22.9	26.8	18.0	1
Shells, clams and oysters	99.2	—	—	—	—	96.7	1
Sugar cane No. 199	15.4	1.6	0.3	5.4	6.4	1.67	1
Sweet potato vines (*Ipomoea batatas* [Linn.] Poir)	14.4	2.0	0.4	3.7	6.3	2.0	2
Tropical kudzu (*Pueraria javanica* Benth.)	21.1	3.4	0.9	8.0	6.4	2.4	2
Water hyacinth (*Eichhornia crassipes* [Mart] Solms)	7.8	1.0	0.3	1.9	3.7	0.9	1

TABLE 2

Chemical composition of livestock feeds (moisture-free basis)

FEEDS	PERCENTAGE COMPOSITION						
	Crude protein	Ether extract	Crude fiber	N-free extract	Ash	Ca	P
Concentrates and roots:							
Cassava roots	2.6	2.1	1.5	90.5	3.3	—	—
Coconut meat (fresh)	9.8	64.5	4.2	18.6	2.9	0.02	0.25
Coconut residue	6.7	5.5	38.2	48.2	1.4	—	—
Copra meal	22.5	8.4	9.5	52.0	7.6	0.10	0.77
Corn gluten feed	24.2	3.4	7.2	64.1	1.1	0.01	0.37
Corn, Yellow Flint	10.9	2.9	2.8	81.5	1.9	0.07	0.39
Fish meal	65.8	3.9	0.6	22.4	7.3	8.36	4.91
Ipil-ipil seeds	30.3	7.9	12.9	44.5	4.4	0.47	0.44
Molasses cane	1.4	1.7	0	86.7	10.2	0.41	0.17
Poñgapong (*Amorphophallus campanulatus* [Roxb] Blm.)	8.6	1.0	5.2	79.8	5.4	0.45	0.19
Rice bran, fine	11.4	12.0	14.0	49.0	13.7	0.03	1.49
Susong papang (meat and shell)	11.9	0.8	1.1	9.7	76.5	—	—
Totong (rice and coconut)	7.4	3.1	0.2	88.7	0.6	—	—
Forages:							
Aguingay (*Rottboellia exaltata* Linn.)	7.7	3.5	34.6	36.8	17.4	0.14	0.63
Alabang X (*Andropogon nodosus* [Willem] Nash.) before heading	5.0	4.1	40.1	38.4	12.4	0.48	0.37
" " " while seeds are forming	5.0	6.9	40.6	36.9	10.6	0.14	0.15
" " " leaves	8.4	3.3	35.1	40.6	12.6	0.35	0.20
" " " stems	2.5	1.0	48.7	39.4	8.4	0.23	0.12
Alfalfa before blooming	24.4	4.1	25.4	35.8	10.3	1.05	0.35
Asis (*Ficus ulmifolia* Lam.)	17.1	2.9	18.8	45.6	15.6	—	—
Bamboo (*Bambusa spinosa* Roxb.)	13.7	0.9	30.8	34.1	20.5	0.22	0.15
Banig (*Panicum flavidum* Retz)	10.9	2.7	29.0	37.5	19.9	0.42	0.19
Barit (*Leersia hexandra* Sw)	7.3	2.3	31.1	43.9	15.4	0.10	0.09
Batao (*Dolichos lablab* Linn.)	20.9	1.2	35.6	30.2	12.1	0.66	1.11
Bulang (*Panicum auritum* Presl)	10.4	1.9	29.4	44.6	13.7	0.18	0.34
Bungalon (*Echinochloa stagnina* Beauv.)	5.7	1.2	33.6	49.1	10.4	0.32	0.36
Calopogonium mucunoides in flower	13.6	5.7	29.7	42.8	8.2	—	—

TABLE 2 (continued)

FEEDS	PERCENTAGE COMPOSITION						
	Crude protein	Ether extract	Crude fiber	N-free extract	Ash	Ca	P
Camote-camotehan (*Ipomoea triloba* Linn. and *Meramia utifolia*)	16.5	1.7	33.6	32.2	16.0	1.32	0.75
Carirawraw (*Digitaria pruriens* [Trin] Busse)	9.3	3.2	33.5	42.5	11.5	0.22	0.42
Casadores leaves (*Synedrella nodiflora* [Linn.] Gaertn.)	18.2	1.6	22.8	36.1	21.3	1.81	0.43
Caturay leaves (*Sesbania grandiflora* Pers)	25.2	4.6	18.0	44.0	8.2	—	—
Centrosema pubescens	18.2	6.0	38.6	28.7	8.5	1.15	0.34
Cogon (*Imperata cylindrica* [Linn.] Beauv.)							
10 days (30 cm. tall)	9.7	2.0	32.9	46.8	8.6	—	—
20 days (45 cm. tall)	10.5	1.9	39.1	40.1	8.4	0.32	0.33
90 days (120 cm. tall)	5.4	2.8	38.0	46.7	7.1	0.17	0.18
Corn fodder	5.4	1.3	39.0	38.7	15.6	0.20	0.36
Corn silage, Yellow Flint, few ears	5.9	3.9	33.2	48.0	9.0	0.18	0.60
Culapé (*Paspalum conjugatum* Berg.)	10.8	2.0	32.0	42.8	12.4	0.32	0.25
Guatemala (*Tripsacum laxum* Nash), 120 cm. tall	8.4	0.9	37.2	42.5	11.0	0.18	0.59
180 cm. tall	5.8	1.4	36.3	47.3	9.2	0.12	0.29
Guinea grass (*Panicum maximum* Jacq.) no flowers	6.8	1.2	39.5	37.5	15.0	0.44	0.42
Gutad (*Echinochloa colonum* [L.] Link)	9.6	3.0	29.7	44.8	12.9	0.22	0.23
Ipil-ipil leaves (*Leucaena glauca* [Linn.] Benth.)	27.3	5.4	18.6	41.3	7.4	1.21	0.25
Molasses grass (*Melinis minutiflora*) Beauv.	6.9	1.2	41.7	40.3	9.9	0.16	0.40
Mungo soilage	15.7	2.8	26.9	41.3	13.3	—	—
Mutha (*Cyperus iria* Linn.)	10.8	2.7	25.9	45.6	15.6	0.44	0.33
Natal grass (*Rhynchelytrum roseum* [Ness] Stapf and Hubb)	5.8	1.9	41.0	42.6	8.7	—	—
Para grass (*Panicum purpurascens* Raddi) 40 cm. tall	13.0	3.3	29.4	41.5	12.8	0.28	0.45
90 cm. tall, not in flower	8.9	2.2	33.6	42.9	12.4	0.29	0.39
120 cm. tall, dry leaves	8.9	1.4	31.7	47.9	10.1	—	—
Penisetum sitosum	9.1	0.8	36.7	35.3	18.1	0.33	0.31
Pulang puwet (*Echinochloa colonum* [L.] Link)	6.0	1.8	40.1	41.8	10.3	—	—
Rice straw	4.2	2.6	31.6	36.8	24.8	0.13	0.12
Shells, clams and oysters	10.4	1.7	35.1	42.0	10.8	—	—
Sugar cane No. 199	—	—	—	—	97.5	35.77	—
Sweet potato vines (*Ipomoea batatas* [Linn.] Poir)	14.0	3.0	25.0	44.6	13.1	1.01	0.70
Tropical kudzu (*Pueraria javanica* Benth.)	15.8	4.6	38.0	30.4	11.2	1.20	0.33
Water hyacinth (*Eichhornia crassipes* [Mart] Solms)	12.1	3.4	24.7	48.1	11.7	1.64	0.53
Water hyacinth silage (plus molasses)	13.4	2.7	21.4	42.3	20.2	2.13	0.45

OUTSTANDING VARIETIES AND FORMS OF PUMMELO, CITRUS GRANDIS (LINN.) OSBECK, IN NINE TOWNS OF THE MOUNTAIN PROVINCE [1]

LORETO G. GOMEZ AND L. G. GONZALEZ

WITH ONE TEXT FIGURE

Of the 50 fruits gathered from the 10 best trees, not one equaled the Siamese pummelo (control) in eating quality. The fruits were attractive in appearance, but they contained relatively low sugar and relatively high acid. The trees were apparently healthy and vigorous and set a fair number of fruits. Although they were somewhat smaller than the Siamese pummelo and not as rapid growers, they might prove to be useful as stocks for other citrus in the Philippines.

A similar study should be conducted in other towns of the Mountain Province.

One way of improving the local pummelo industry is to select outstanding varieties and forms and distribute them as foundation stocks. So far, there are only a few named varieties, some of them not even conforming to accepted horticultural nomenclature. It would be of both scientific and practical importance if outstanding pummelo seedling trees could be selected from among those that have shown good performance and described and named according to accepted international horticultural nomenclature.

Nine important fruit-growing towns within reach of road transportation in Benguet, Mountain Province, were surveyed for outstanding varieties and forms of pummelo. The important characteristics of the pummelos were studied, and new forms which might be worthy of asexual propagation were described. The survey lasted from December, 1952, to February, 1954. The analyses, chemical and pomological, were performed in the Departments of Agronomy and Chemistry, College of Agriculture, Los Baños, Laguna.

MATERIALS AND METHODS

This study was based on the hypothesis that because of the prevalent practice of our elders of planting pummelo seeds taken from fruits which have attracted them as being of unusually superior taste, there are in existence, in some secluded localities, some forms or varieties that have inherited desirable qualities. While this method of selection presents difficulties in identifying parentage, it saves the time which is spent in building new pedigrees from seeds.

---

[1] Central Experiment Station Contribution No. 1759. Thesis presented for graduation with the degree of Bachelor of Science in Agriculture. Prepared in the Department of Agronomy under the direction of the junor author.

The survey areas were chosen according to the number of trees grown in the localities. Information was acquired from agricultural agents, municipal officials, teachers, and leading citizens, particularly those who were citrus enthusiasts. The places surveyed were Dacklan, Acnal, Pangued, Dibo-ong, Karao, Bisal, Otbong, Ambuclao, Langoyan, Canubas, Acnip, Bolo, Kamangaan, Adaway, Ansingsing, Intowangan, and Magangan in the town of Bokod; Mambolo in Itogon and the towns of Atok, La Trinidad, Kapangan, Buguias, Mankayan, Kabayan, and Sablan.

Because many trees had to be visited, only one fruit from each tree was tasted in the field. The trees examined were properly indexed. Samples from trees which did not come up to the standard of the Siamese pummelo were so marked on the list. From each of the trees bearing fruits which were considered to be of good quality, at least five fruits were selected at random, marked, wrapped, carefully packed in wooden boxes, and brought to the College for pomological and chemical tests.

At the College, the samples were again tasted by a panel of three judges. The best ten were given scores of 1 to 10, depending on the respective ranks given by the judges. The points for each fruit were summed up, and the five fruits with the highest scores were considered in the final selection. These were analyzed for pomological characteristics, such as the color of rind and general attractiveness, ease of separation from the rag, texture, seediness, and percentage of pulp, and for chemical composition. The opinions of the judges on taste were included. The final evaluation of quality was based on a composite of the leading characters enumerated.

Chemical analyses for total reducing sugars and titratable acidity were run according to the methods of AOAC.[2]

RESULTS AND DISCUSSION

Dimension and percentage of edible portions were not analyzed statistically, but the following characters of the varieties and forms which were studied for desirability gave highly significant mean squares:

1. Weight of fruit (table 3)
2. Thickness of rind (table 4)
3. Weight of rind (table 5)
4. Weight of rag (table 7)
5. Number of seeds (table 8)
6. Weight of seeds (table 9)
7. Amount of total reducing sugar (table 11)
8. Titratable acidity (table 12)

The forms studied varied in the characters listed above. The fruits with the highest points were those taken from the orchards of Honorable Denis Molintas in Acnal, Dacklan, Bokod; Calixto Oc-

[2] H. A. Lepper (ed.), "Official Methods of Analysis of Association of Agricultural Chemists," AOAC, Washington 4, D.C., 1950, 7th ed., 910 pp.

taviano in the same barrio; Kerese Libag in Canubas, Bokod; Luis Angel in Intowangan, Bokod; and Ayatan Erico in Dibo-ong, Bokod (table 1).

It is interesting to note the perfect agreement of the members of the panel on their selections on the basis of sugar-acid ratio (table 1a). On this basis, the tree adjudged the best was not significantly better than the control, which was the Siamese variety (table 14). Based on the physical analysis of the fruits of the five selected forms, tree No. 5 (owned by Ayatan Erico) had the largest fruit and tree No. 2 (owned by Calixto Octaviano), the smallest (table 2). Tree No. 4 (owned by Luis Angel) had the thickest rind. In number of segments (table 6), tree No. 1 (owned by Denis Molintas) had as many as tree No. 3 (owned by Kerese Libag). All the five forms were seedy. In quantity of edible portion, tree No. 5 had the biggest; tree No. 1, the second biggest; tree No. 3, the smallest (table 10).

The control had significantly the least titratable acidity, which does not necessarily mean that it has the best eating quality. The amount of reducing sugars also cannot be used as an indication of eating quality (table 12).

Based on their juice-pulp ratio, none of the five selected forms was as juicy as the Siamese pummelo. The driest was the tree owned by Kerese Libag (table 13).

The results of this study corroborate the statement of Dean Leopoldo B. Uichanco that the pummelos he has tasted in the Mountain Province and neighboring places are sour. The fruits of the Siamese variety used as control were not grown in the Mountain Province but were obtained from the Exconde plantation in Calauang, Laguna. How this variety will taste when grown at a high elevation like the forms studied can only be guessed at; the subject may serve for a separate study. Multiplication of the Denis Molintas tree will be beneficial to the region, and this form may be used as the temporary standard while others, perhaps better tasting and better yielding than the Siamese, are being studied for adaptability to conditions in Benguet.

Farmers should consider the yield of a tree in addition to its eating quality. Even if a fruit form possesses market quality, its prolificacy should be taken into account before it is recommended for commercial planting. This basis for recommendation was not included in the present study because it was not possible to keep track of the yields of each tree.

The pomological descriptions of the outstanding forms (fig. 1) are as follows:

1. Denis Molintas tree—The thick, firm outer rind is lime yellow in color, has a uniform surface, and is finely papillate. The fruit is large, with the shape varying from globose to slightly ellipsoid, the base being almost evenly rounded. The inner rind is thick and

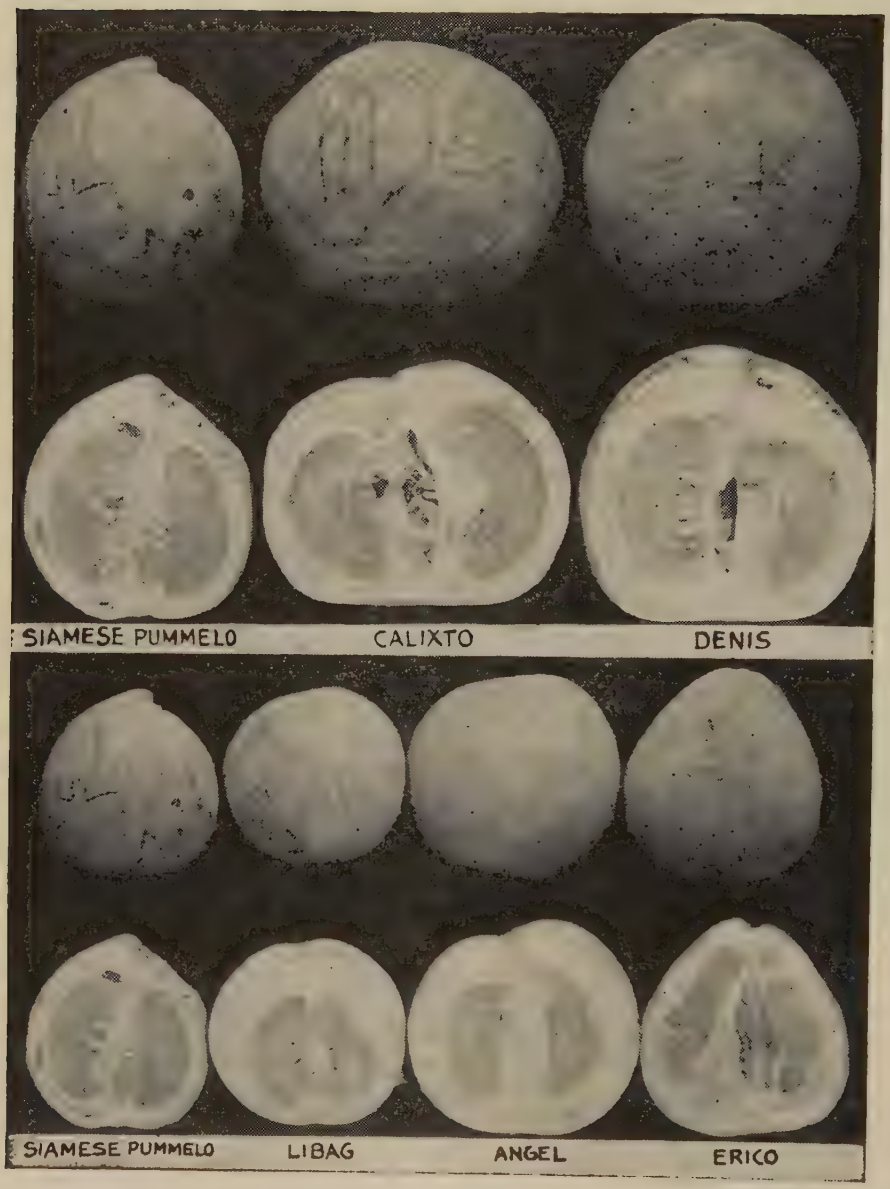

Fig. 1.—Shapes and longitudinal cross sections of some of the outstanding varieties and forms of pummelo in Benguet. (*Photographed by the Photographic Division*).

firm. The pulp is uniform in color, with medium texture and large vesicles. The segments number 12 to 15. The edible portion is juicy and is of somewhat subacid flavor. The fruit has several seeds. The tree bears fruit early. The shipping quality of the fruit is excellent.

2. Calixto Octaviano tree—The outer rind is mustard yellow, has a uniform surface, and is finely papillate. The fruit is large, its base moderately depressed. It has a fairly thick inner rind. The number of segments ranges from 12 to 14. The pulp is uniform in color and has a medium texture. The vesicles are large, juicy, and somewhat subacid in flavor. This form contains numerous seeds. It sets fruit early and is of good shipping quality.

3. Kerese Libag tree—The thick, fine rind is buff yellow and has a smooth, uniform surface. The shape varies from spherical to slightly obovate. The fruit is medium-sized and low-collared and has a depressed base. The number of segments is from 10 to 12. The pulp is uniform, is of medium texture, and has medium-large vesicles. It is juicy and of a subacid flavor. The fruit has many seeds.

4. Luis Angel tree—The rind is uniform buff yellow, with a smooth surface. The fruit is medium-sized, its shape oblate to obovate, with a moderately depressed base. The inside rind is very thick and firm. The pulp is uniform in color and has a medium texture. The vesicles are medium large. The number of segments varies from 14 to 15. The fruit is juicy but is of a subacid flavor. It has many seeds.

5. Ayatan Erico tree—The surface rind is barium yellow, is uniform, and is finely papillate. The fruit is medium-sized, oblate to obovoid in shape, with a low-collared base. It has a firm and fairly thick inner rind. The number of segments ranges from 10 to 12. The pulp is of uniform color, with medium texture and medium-sized vesicles. It is juicy and subacidic in flavor. The fruit has few seeds.

TABLE 1

Quality ranking, owner, and location of 10 select varieties of pummelo in the Mountain Province

TREE NO.	OWNER	LOCATION	RANKING (BY PANEL)
I	Denis Molintas	Acnal, Daclan, Bokod	1st
II	Ayatan Erico	Dibo-ong, Bokod	5th
III	Luis Angel	Intowangan, Bokod	4th
IV	Kerese Libag	Canubas, Bokod	3rd
V	Calixto Octaviano	Acnal, Dacklan, Bokod	2nd
VI	Tigio Suayan	Dacklan, Bokod	10th
VII	Inimag Moren	Pangued, Dacklan, Bokod	6th
VIII	Erena Bayeng	Bokod Central	7th
IX	Luiso Wasit	Karao, Bokod	9th
X	Serapino Dorot	Pangued, Dacklan, Bokod	8th

TABLE 1a

Results of taste test of 10 outstanding forms of pummelo

OWNER	PLACING BY PANEL						TOTAL POINTS
	X		Y		Z		
	Rank	Points (1-10)	Rank	Points (1-10)	Rank	Points (1-10)	
Denis Molintas	1	10	2	9	1	10	29
Tigio Suayan	10	1	9	2	10	1	4
Luis Angel	4	7	4	7	4	7	21
Kerese Libag	3	8	3	8	3	8	24
Calixto Octaviano ..	2	9	1	10	2	9	28
Ayatan Erico	5	6	5	6	5	6	18
Inimag Moren	6	5	6	5	6	5	15
Erena Bayeng	8	3	7	4	7	4	11
Luiso Wasit	9	2	10	1	9	2	5
Serapino Dorot	7	4	8	3	8	3	10

TABLE 2

Length × width of fruits in centimeters

FRUIT NO.	NUMBER OF TREE									
	I	II	III	IV	V	VI	VII	VIII	IX	X
1	15.7×16.6	15.8×15.4	16.2×16.0	13.7×13.8	13.6×18.1	11.4×12.1	11.6×11.5	11.9×15.6	11.2×13.3	13.1×12.8
2	15.4×15.8	16.1×15.7	14.1×14.6	13.8×13.9	12.6×15.5	11.7×12.4	11.4×11.4	11.8×15.4	10.8×10.3	13.2×13.6
3	15.1×15.6	15.7×15.3	16.1×15.8	13.7×13.8	13.2×17.5	11.6×12.3	12.2×12.4	11.8×15.6	11.2×10.4	13.8×13.6
4	15.6×16.2	15.8×15.6	16.1×15.9	13.6×13.6	12.7×15.6	11.8×12.2	12.4×12.5	10.9×14.8	11.3×10.7	13.2×12.8
5	15.2×15.4	15.7×15.4	16.1×16.1	13.5×13.6	13.4×17.9	11.5×12.1	11.8×12.0	11.2×15.2	12.6×11.1	13.1×12.9
Mean	15.4×15.9	15.8×15.5	15.7×15.7	13.7×13.7	13.1×16.9	11.6×12.2	11.9×12.0	11.5×15.3	11.4×10.6	13.3×13.1

TABLE 3

Weight of fruits in grams

FRUIT NO.	NUMBER OF TREE										TOTAL	MEAN
	I	II	III	IV	V	VI	VII	VIII	IX	X		
1	1364.3	981.0	1096.0	889.9	1555.1	972.9	987.9	1299.8	956.6	991.6	11095.1	1109.51
2	1286.4	991.6	1013.5	911.2	1392.2	899.3	976.6	1284.2	967.5	989.7	10712.2	1071.22
3	1246.7	982.2	1097.2	862.7	1547.1	998.3	998.1	1274.7	962.3	999.5	10968.8	1096.88
4	1347.5	981.9	1087.3	829.7	1557.3	968.6	1021.2	1316.4	897.9	982.6	10990.4	1099.04
5	1238.6	978.2	1069.3	838.1	1549.6	986.5	986.4	1171.9	991.4	958.7	10768.7	1076.87
Total	6483.5	4914.9	5363.3	4331.6	7601.3	4825.6	4970.2	6347.0	4775.7	4922.1	54535.2	
Mean	1296.7	983.0	1072.7	866.3	1520.3	965.1	994.0	1269.4	955.1	984.4		

Analysis of variance

SOURCE OF VARIATION	DF	SS	MS	COMPUTED F-VALUE	TABULAR F-VALUE	
					5%	1%
Trees	9	1,879,761.76	208,862.418	120.787	2.12	2.88
Fruits on trees	40	69,167.42	1,729.186			
Total	49	1,948,929.18				

M.D. at 1% level = 71.12.

TABLE 4

Thickness of rind in centimeters

FRUIT NO.	NUMBER OF TREE										TOTAL	MEAN
	I	II	III	IV	V	VI	VII	VIII	IX	X		
1	2.2	1.9	2.2	2.1	1.8	1.8	1.8	1.8	2.0	1.9	19.5	1.95
2	2.2	1.8	2.3	2.1	1.8	1.9	1.9	1.9	2.1	2.0	20.0	2.00
3	2.1	1.8	2.2	2.2	1.8	1.8	1.8	1.8	2.0	2.0	19.5	1.95
4	2.2	1.9	2.2	2.1	1.7	1.8	1.9	1.8	2.0	1.9	19.5	1.95
5	2.2	1.9	2.3	2.1	1.8	1.9	1.8	1.8	2.0	2.0	19.8	1.98
Total	10.9	9.3	11.2	10.6	8.9	9.2	9.2	9.1	10.1	9.8	98.3	
Mean	2.2	1.9	2.2	2.1	1.8	1.8	1.8	1.8	2.0	2.0		

Analysis of variance

SOURCE OF VARIATION	DF	SS	MS	COMPUTED F-VALUE	TABULAR F-VALUE	
					5%	1%
Trees	9	1.232	0.137	54.80	2.12	2.88
Fruits on trees	40	0.100	0.025			
Total	49	1.332				

M.D. at 1% level = 0.08.

TABLE 5

Weight of rind in grams

FRUIT NO.	NUMBER OF TREE										TOTAL	MEAN
	I	II	III	IV	V	VI	VII	VIII	IX	X		
1	456.2	344.3	500.8	367.7	430.2	364.1	278.9	355.0	288.1	279.7	3665.0	366.50
2	434.2	326.7	497.7	379.2	410.6	371.6	298.1	351.2	267.6	251.7	3588.6	358.86
3	412.3	331.5	502.9	345.1	426.5	324.5	286.7	352.6	271.3	281.0	3534.4	353.44
4	448.7	324.6	509.7	321.7	432.6	348.1	286.4	349.7	281.2	262.4	3565.1	356.51
5	454.1	356.6	501.6	335.9	429.7	381.2	296.5	346.9	278.7	264.6	3645.8	364.58
Total	2205.5	1683.7	2512.7	1749.6	2129.6	1789.5	1446.6	1755.4	1386.9	1339.4	17998.9	
Mean	441.1	336.7	502.5	349.9	425.9	357.9	289.3	351.1	277.4	267.9		

Analysis of variance

SOURCE OF VARIATION	DF	SS	MS	COMPUTED F-VALUE	TABULAR F-VALUE	
					5%	1%
Trees	9	261,373.673	29,041.519	149.157	2.12	2.88
Fruits on trees	40	7,788.232	194.705			
Total	49	269,161.905				

M.D. at 1% level = 23.85.

TABLE 6

Number of segments of fruits

FRUIT NO.	NUMBER OF TREE									
	I	II	III	IV	V	VI	VII	VIII	IX	X
1	14	10	14	11	14	10	11	14	10	11
2	14	11	15	12	13	11	12	13	11	10
3	12	10	14	11	14	11	11	11	10	11
4	15	12	15	10	12	10	12	12	10	10
5	14	11	14	10	14	11	12	15	12	11
Mean	14	11	14	11	13	11	12	13	11	11

TABLE 7

Weight of rag in grams

FRUIT NO.	NUMBER OF TREE										TOTAL	MEAN
	I	II	III	IV	V	VI	VII	VIII	IX	X		
1	155.1	103.1	104.5	89.6	209.9	112.0	156.1	174.2	132.6	155.6	1392.7	139.27
2	148.7	99.8	104.8	86.2	189.6	101.6	169.7	171.3	124.7	161.4	1357.8	135.78
3	145.3	102.6	103.9	80.1	206.8	107.8	181.7	166.7	131.9	168.1	1394.9	139.49
4	149.9	104.5	105.7	94.7	208.7	100.5	186.3	168.4	128.3	178.4	1425.4	142.54
5	145.7	112.0	104.9	84.6	209.1	118.8	161.9	152.7	134.6	156.8	1381.1	138.11
Total	744.7	522.0	523.8	435.2	1024.1	540.7	855.7	833.3	652.1	820.3	(6951.9)	
Mean	148.9	104.4	104.8	87.0	204.8	108.1	171.1	166.7	130.4	164.1		

Analysis of variance

SOURCE OF VARIATION	DF	SS	MS	COMPUTED F-VALUE	TABULAR F-VALUE	
					5%	1%
Trees	9	64,762.278	7,195.809	134.559	2.12	2.88
Fruits on trees	40	2,139.060	53.477			
Total	49	66,901.338				

M.D. at 1% level = 12.49.

TABLE 8

Number of seeds to a fruit

FRUIT NO.	NUMBER OF TREE										TOTAL	MEAN
	I	II	III	IV	V	VI	VII	VIII	IX	X		
1	76	14	146	94	90	61	74	72	67	67	761	76.1
2	67	16	132	90	81	68	81	68	73	76	752	75.2
3	72	15	119	89	87	73	67	59	71	69	721	72.1
4	77	19	138	88	91	69	78	76	61	71	768	76.8
5	74	21	142	82	89	76	79	71	64	77	775	77.5
Total	366	85	677	443	438	347	379	346	336	360	(3777)	
Mean	73	17	135	89	88	69	76	69	67	72		

Analysis of variance

SOURCE OF VARIATION	DF	SS	MS	COMPUTED F-VALUE	TABULAR F-VALUE	
					5%	1%
Trees	9	37,458.420	4,162.047	131.502	2.12	2.88
Fruits on trees	40	1,266.000	31.650			
Total	49	38,724.420				

M.D. at 1% level = 9.60.

TABLE 9

Weight of seeds in a fruit in grams

FRUIT NO.	NUMBER OF TREE										TOTAL	MEAN
	I	II	III	IV	V	VI	VII	VIII	IX	X		
1	41.8	11.2	52.8	14.0	30.2	30.1	30.7	28.4	29.8	31.5	300.5	30.05
2	39.8	12.6	48.6	13.2	27.6	32.4	32.8	27.6	28.4	34.4	297.4	29.74
3	39.7	11.7	42.9	13.4	30.1	29.9	30.6	26.8	29.7	34.8	289.6	28.96
4	10.2	13.1	49.2	13.5	32.9	28.7	34.5	29.1	30.1	33.6	274.9	27.49
5	41.3	16.8	49.8	14.2	29.1	31.4	35.6	28.2	27.8	38.1	312.3	31.23
Total	172.8	65.4	243.3	68.3	149.9	152.5	164.2	140.1	145.8	172.4	(1474.7)	
Mean	34.6	13.1	48.7	13.7	30.0	30.5	32.8	28.0	29.2	34.5		

Analysis of variance

SOURCE OF VARIATION	DF	SS	MS	COMPUTED F-VALUE	TABULAR F-VALUE	
					5%	1%
Trees	9	4,763.616	529.291	23.780	2.12	2.88
Fruits on trees	40	890.332	22.258			
Total	49	5,653.948				

M.D. at 1% level = 8.06.

TABLE 10

Percentage of edible portion in a fruit

FRUIT NO.	NUMBER OF TREE										TOTAL	MEAN
	I	II	III	IV	V	VI	VII	VIII	IX	X		
1	52.13	53.25	39.95	47.03	56.91	47.97	52.86	57.10	52.91	52.92	513.03	51.30
2	51.60	54.71	45.62	47.47	54.90	48.90	48.54	57.16	56.52	54.78	520.20	52.02
3	52.09	54.61	40.78	49.16	57.12	53.70	50.00	57.16	55.01	51.58	521.21	52.12
4	52.60	54.97	38.88	48.19	56.71	50.72	51.31	55.01	51.04	51.72	511.15	51.11
5	49.05	54.98	38.51	48.13	56.90	46.13	49.92	54.94	55.51	52.07	506.14	50.61
Total	257.47	272.52	203.74	239.98	282.54	247.42	252.63	281.37	270.99	263.07		
Mean	51.49	54.50	40.75	47.99	56.51	49.48	50.53	56.27	54.20	52.61		

TABLE 11

Amount of total reducing sugar (as invert) to every 100 ml. of undiluted juice

NUMBER OF TRIAL	FRUIT NUMBER					CONTROL	TOTAL	MEAN
	I	II	III	IV	V			
1	826.25	542.13	342.33	471.95	440.58	615.33	3238.57	539.76
2	830.96	518.06	345.58	454.31	439.26	629.95	3218.12	536.35
3	835.72	539.09	345.17	462.96	435.54	617.94	3236.42	539.40
Total	2492.93	1599.28	1033.08	1389.22	1315.38	1863.22	9693.11	
Mean	830.98	533.09	344.36	463.07	438.46	621.07		

Analysis of variance

SOURCE OF VARIATION	DF	SS	MS	COMPUTED F-VALUE	TABULAR F-VALUE	
					5%	1%
Trees	5	437,333.133	87,466.627	1,530.930	3.11	5.06
Fruits on trees	12	685.592	57.133			
Total	17	438,018.725				

M.D. at 1% level = 18.85.

TABLE 12

Acidity expressed in ml. of N/10 NaOH to 100 ml. of undiluted juice

NUMBER OF TRIAL	NUMBER OF TREE					CONTROL	TOTAL	MEAN
	I	II	III	IV	V			
1	217.60	196.00	241.33	245.60	176.40	162.67	1239.60	206.60
2	218.00	188.00	238.12	244.70	180.00	154.60	1223.42	203.90
3	211.04	218.00	239.16	245.23	178.82	164.32	1256.57	209.43
Total	646.64	602.00	718.61	735.53	535.22	481.59	3719.59	
Mean	215.55	200.67	239.54	245.18	178.41	160.53		

Analysis of variance

SOURCE OF VARIATION	DF	SS	MS	COMPUTED F-VALUE	TABULAR F-VALUE	
					5%	1%
Fruits on trees	5	16,816.583	3,363.317	69.607	3.11	5.06
Trees	12	579.831	48.319			
Total	17	17,396.414				

M.D. at 1% level = 17.32.

TABLE 13

Juice-pulp ratio

OWNER OF TREE	RATIO
Denis Molintas	1.69:1
Octaviano Calixto	2.07:1
Kerese Libag	1.65:1
Luis Angel	2.66:1
Ayatan Erico	2.55:1
Siamese (control)	2.82:1

TABLE 14

Sugar-acid ratio

OWNER OF TREE	SUGAR	ACID	RATIO
Denis Molintas	830.98	215.55	3.85:1
Octaviano Calixto	533.09	200.67	2.66:1
Kerese Libag	438.46	178.41	2.46:1
Luis Angel	463.07	245.17	1.89:1
Ayatan Erico	344.36	239.54	1.44:1
Siamese (control)	621.07	160.53	3.77:1

THE PERFORMANCE OF THE ENSILAGE HARVESTER [1]

ALEJANDRO M. CATAMBAY AND ALEJANDRO B. CATAMBAY

The amount of silage obtained from one hectare of corn was 19.1 tons in the wet season and 12.0 tons in the dry season; the cost was ₱219.04 in the wet season and ₱185.46 in the dry season. One ton of silage cost ₱11.47 to produce in the wet season and ₱15.46 in the dry season.

The actual capacity of the ensilage harvester was 7.5 tons an hour in the wet season and 5.0 tons in the dry season. The blower capacity in elevating the fodder into the silo was 10.2 tons an hour.

Weeds constituted 5.2 per cent of the chopped material in the wet season and 2.1 per cent in the dry season. The moisture content of the fodder at harvest was 65.5 per cent in the wet season and 66.3 per cent in the dry season; that of the silage, 70.5 per cent in the wet season and 68.1 per cent in the dry season. The silage produced was very well relished by the stock.

The first corn ensiling experiments at Los Baños were conducted in 1929. Esguerra [2] then used a Hocking Valley blower-cutter to fill a cylindrical concrete tower silo. He repeated the work from 1937 to 1938, this time operating a McCormick-Deering blower-cutter, and reported an average cost of ₱17.18 to produce a ton of corn silage. In 1949, Juliano, Jr.[3] used a blower-cutter of a later design (I.H.C. No. 7) and reported an average cost of ₱16.48 to produce a ton. Although these studies have already yielded valuable information on successful ensiling of corn which farmers who want to raise more animal feeds on small areas may find useful, the cost of making silage will continue to interest these farmers greatly.

Recently, the College acquired an ensilage harvester, probably the first machine of its kind in the Philippines, which is expected to reduce the labor requirement in harvesting and ensiling corn and, consequently, the cost of making the silage. To determine the quality of work done by this machine, the cost of operation, and the cost of producing one ton of corn silage, this study was conducted in the Departments of Agricultural Engineering and Animal Husbandry, College of Agriculture, from May, 1952, to February, 1954.

MATERIALS

The seeds

Seeds of Catambay's Cuban from the previous harvest of the mechanized corn culture experiment in the College were used. This

---

[1] Central Experiment Station Contribution No. 1760. Condensed from the thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture. Prepared in the Department of Agricultural Engineering under the direction of the junior author.

[2] J. P. Esguerra, *Philippine Agriculturist*, 29, 327 (1940).

[3] C. P. Juliano, Jr., "A Study of the Performance of I.H.C. No. 7 Ensilage Cutter." (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, 1949. Unpublished.)

variety of corn is described as a strain developed by the junior author from his selection from the progenies of the varietal crosses he made between Cuban Yellow Flint and College Yellow Flint immediately after World War II. Because this strain has been found to perform well in Los Baños, it has always been used as a check in the yield trials of the Division of Plant Breeding of the College.[4]

The machinery and implements

Tractors. Three tractors were used in this study. The first, a 24-28 h.p. tractor, has rubber tires, starts on gasoline, and runs on kerosene. It was used for plowing, harrowing, planting, cultivating, and furnishing power to the blower. The second tractor, a 12-18 h.p. one, has rubber tires and operates on gasoline. It was used in hauling fodder from the field to the blower. The third, a 34-38 h.p. tractor, also has rubber tires and starts on gasoline and runs on kerosene. It was used to furnish power to the ensilage harvester and, simultaneously, to pull a wagon trailing behind the harvester to receive the fodder.

Plow. A 2-26-inch tractor-mounted disk plow which is raised and lowered by a hydraulic lifting device mounted on the tractor was used in plowing the field.

Harrows. An 8-foot 28-16-inch double gang disk harrow and a 2-4-foot section steel peg tooth harrow were placed tandem, with the peg tooth harrow trailing behind the disk harrow.

Corn planter. A 2-row tractor-mounted machine which can be raised and lowered by means of the hydraulic lifting device was used in planting.

Cultivator. A 2-row tractor-mounted cultivator provided with sweep blades and disk hillers was used in cultivating the crops. This machine is raised and lowered by the hydraulic lifting device of the tractor.

Ensilage harvester. The harvester performs these operations simultaneously: gathering the plants in the row and cutting them at the base, chopping the plants into fodder, and delivering the fodder into a trailing wagon. The machine is mounted on two rubber tires and hitched to a tractor which provides the power to operate the machine and pull both the harvester and the wagon as a unit. The length of cut of the fodder can be adjusted from ½ inch to 3½ inches.

Wagons. Three all-purpose trucks, commonly called wagons, were used in hauling the fodder from the field to the blower which is installed near the silo. Each truck is mounted on four pneumatic tires which make hauling convenient. The wagons range from ¾ to 1 ton in capacity.

---

[4] Information supplied by Dr. Dioscoro L. Umali of the Department of Agronomy.

Blower. The blower consists of two main parts, the auger and the blower fan. The power was furnished by the 24-28 h.p. tractor.

Tachoscope. This instrument is a combination of revolution counter and stop watch. It was used to check the r.p.m. of the tractor and blower pulleys while in operation to keep them within safe operating limits.

Transit-level, tape, and stadia board. These instruments were used to determine the area of the field planted to the crop and the height of the plants.

Scale. A scale with a capacity of more than the weight of the fodder-loaded wagon was used in determining the weight of the materials for ensiling.

Silo. The silo used is of the cylindrical-tower type, 33 feet high with a 10-foot inside diameter. It is made of concrete and is estimated to last for 50 years.

The field

Four hectares of Lipa clay loam soil were prepared and planted to corn in each culture. The area was estimated to furnish sufficient fodder to fill the silo. Actually, 2.424 hectares of the crop were used in the wet-season ensiling and 3.875 hectares in the dry-season ensiling. No fertilizer was applied because the field had previously been used as a pasture.

METHODS

Preparation of the land. In May, 1952, the land for the wet-season culture was plowed twice, with an interval of two weeks between operations. Each plowing was immediately followed by harrowing. The plowings and harrowings for the dry-season culture were done in November, 1952.

Planting. The wet-season crop was planted on May 27, 1952; the dry-season crop, on December 5, 1952. The planter was so adjusted as to drop three to five seeds in a hill at a distance of 28 inches (71.1 cm.) between hills and 42 inches (106.7 cm.) between the rows. This adjustment plants an average of 6 gantas to a hectare, which is slightly higher than the rate used by Catambay [5] when he raised corn for grain.

Cultivation. The wet-season crop was first cultivated on July 10, 1952, with the use of sweep blades attached to the cultivator. The second cultivation, with the use of a combination of sweep blades and disk hillers, followed a week later. The dry-season crop was first cultivated on January 8, 1953. The delay in the operation was due to the inclement weather in late December. Because the plants were already tall, the first cultivation was immediately followed by the second, which hilled-up the plants.

Harvesting. The wet-season crop was harvested intermittently from September 4 to 20, 1952, because of inclement weather. The

[5] A. B. CATAMBAY, *Philippine Agric. Engin. Jour.*, 1, 17 (1950).

wet field did not permit the satisfactory operation of the ensilage harvester. Three wagons were used alternately in hauling the fodder to the blower. The dry-season crop was harvested from March 12 to 16, 1953, also with some interruptions.

Elevating and compacting of fodder in the silo. Before the silo was filled, a layer of rice straw about three inches thick was spread at the bottom of the silo to prevent contact of the fodder with the concrete bottom and to plug the drainage hole. The fodder was weighed and then dumped into the auger housing of the blower. From there, it was forced by the auger into the fan housing. The fodder was then blown up through the pipe into the silo by a fast revolving fan. At the top of the silo, the fodder was caught in a funnel, or distributor bucket, connected to the distributor pipe (in 3-foot sections) which runs down the whole length of the silo. The bucket and the pipe can be swung around inside the silo so that the fodder can be spread evenly with practically the same degree of compactness. When the fodder had been accumulated to a depth of 3 feet inside the silo, blowing was stopped and two men trampled on the fodder to pack it further. The fodder was sprayed with water while it was thus being packed. This operation was repeated at every 3-foot depth until the silo was filled. The crevices of the doors were sealed with jute against air.

Determination of moisture content of fodder and silage. Samples of fresh fodder were collected at harvest time from each culture and were placed in Mason jars, then tightly sealed, and brought to the chemical laboratory of the experiment station for the determination of the moisture content. Likewise, samples of the silage removed from the silo to be fed to the animals in the Department of Animal Husbandry were brought to the laboratory for the same analysis.

Determination of percentage of weeds in the fodder. At harvest in each season, samples of fresh fodder were taken from the wagon and brought to the physics laboratory, Department of Agricultural Engineering, where the chopped weeds were separated from the fodder and the two weighed separately. The percentage of chopped weeds in the mass was then computed.

Determination of capacity of harvester and blower. The capacity of the ensilage harvester, expressed in tons of fodder harvested in one hour, was determined in several trials in which the time it took to fill the wagon with fodder and the weight of the fodder were taken.

The capacity of the blower, expressed in tons of fodder elevated into the silo in one hour, was determined in several trials on taking the time to blow a wagonload of known weight into the silo. The tests were made in both seasons.

RESULTS AND DISCUSSION

Condition of the crop before harvesting. In the wet-season culture the plants were vigorous, the large stalks ranging in height from

6 to 10 feet. Many plants bore two ears covered with closely drawn husks. The height of the first ear from the ground ranged from 3 to 5 feet. Because of the strong winds that occurred earlier, many plants leaned toward the east. Some broken plants were observed in the field and, upon examination, many were found attacked by the corn borer, *Pyrausta nubilalis*. In spite of the two cultivations, the weeds grew thickly, especially in the spaces between the hills of corn. *Amaranthus spinosus* L. was the most predominant. *Calopogonium mucunoides* Desv., *Centrosema pubescens* Benth., and *Ipomoea tribola* L. were found coiled around the plants. The other weeds observed were katuhod (*Cclosia argentea* L.) and aguingay (*Roettboellia exaltata* L.).

The plants in the dry-season culture, although also vigorous, appeared stocky, their heights ranging from 4.5 to 7 feet. The stalks were upright. Only a few plants bore two full ears. The same species of weeds were observed in the field, but they did not grow so thickly as in the wet season.

The chopped weeds that were with the corn fodder of the wet-season crop constituted 5.2 per cent of the mass; those with the dry-season fodder represented 2.1 per cent. The heavy crop in the wet-season culture made the percentage of weeds in the harvested fodder low in spite of the thick growth of weeds in that culture.

The ages of the plants at harvest were 100 days in the wet-season culture and 97 days in the dry-season culture. At this stage the kernels were already becoming hard, but the plants were still in luxuriant growth. The moisture content of the fresh fodder, which may be considered as representative of the whole plant, was 65.5 per cent for the wet-season crop and 66.3 per cent for the dry-season crop.

According to Smith and Davis,[6] corn is at its best for ensiling when the kernels are just beginning to harden and the lower leaves of the plant are turning brown. At this time the moisture content of the whole plant is between 65 and 70 per cent.

Field operations. The wetness of the soil after each heavy rain during the harvesting period in the wet season was the main cause of the delay in the field operations requiring the use of the ensilage harvester. Thick vines that coiled around the corn plants sometimes choked the harvester and caused interruption of the work. The upstanding plants were easily cut, leaving clean-cut stumps of about eight inches, but the lodged plants were not picked and might be considered a loss in harvesting. When the plants were leaning in the direction of travel of the machine, the stumps left were 15 to 20 inches high. The harvester left a clean swath, cutting both plants and weeds in its path. Smith and Davis [7] consider ensiling as one way to kill weed seeds and prevent the spread of the viable ones.

---

[6] F. L. Smith and L. L. Davis, *University of California Exper. Sta. Cir.*, 411 (1952).

[7] *Ibid.*

It was noted that the tractor had enough power to operate the harvester and pull the loaded wagon of fodder at the same time. Operation was done on the second gear and at full throttle opening. Two miles an hour was found to be a satisfactory operating speed, but where the crop was heavy with a thick growth of weeds, the speed was reduced to one mile an hour to avoid choking of the machine.

The dry ground and the upstanding plants contributed to the satisfactory operation of the tractor and the harvester during the dry season. The stumps left were about six inches high. The throttle opening and the speed used in the wet season were also employed in the dry-season harvesting.

The tests showed that the actual rate of harvesting based on straight runs was 7.5 tons an hour in the wet season and 5 tons in the dry season. Because of the heavier crop in the wet season, it took a shorter time to fill the wagon than in the dry season. The blower, with an average fan pulley r.p.m. of 796, elevated the fodder at an average rate of 10.2 tons an hour. A very slight difference was noted between the rates of elevating the fodder into the silo in the wet and dry seasons.

Quality of silage. The harvester was adjusted to cut the fodder to ½-inch lengths so as to allow a more thorough packing of the mass in the silo. Aside from trampling, additions of layers of fodder increased the pressure on the mass and subsequently expelled the air entrapped in the fodder.

The average temperature of the mass in the silo was 43.9°C. in the wet season and 44.1°C. in the dry season. According to Esguerra,[8] Eckles, Oshel, and Magruder pointed out that good silage is produced within the temperature range of 50°F. to 100°F. (10°C. to 47.78°C.).

The average moisture content of the silage removed from the silo was 70.5 per cent in the wet season and 68.1 per cent in the dry season. Both figures were slightly higher than those obtained with the fresh fodder at the time of filling the silo. The average moisture content of the fresh fodder was 65.5 per cent in the wet season and 66.3 per cent in the dry season. The silage made in both seasons was well relished by the animals.

Spoilage of silage. The silage from the wet-season crop was stored for five months, and that from the dry-season crop, four months. Spoiled silage constituted 2.2 per cent of the entire mass in the wet-season ensiling and 1.8 per cent in the dry-season ensiling.

King[9] reported that the depth of the silo influences the amount of waste or spoilage in ensiling and that the best results can hardly be secured with a depth less than 24 feet. The silo used in this study is 33 feet deep. This depth gives enough pressure on the silage which contributes to the expulsion of the entrapped air. The pro-

[8] Esguerra, *op. cit.*
[9] F. H. King, *University of Wisconsin Agric. Exper. Sta. Bull.*, 28 (1891).

portion of exposed area on the top of the stored silage to the total mass in the silo is also very small. The spoiled silage removed from the silo was obtained mostly from the top of the column.

Cost of raising one hectare of corn for ensiling. The total labor required from land preparation up to cultivation in the wet season and in the dry season is shown in table 1 together with the corresponding labor costs.

The charges for the use of machinery, including depreciation, interest on investment on the equipment, and fixed charges for housing and repair, in the wet season and in the dry season (table 2) were greater than the labor costs.

The cost of raising one hectare of the crop (table 3) included labor, charges for use of equipment, seeds, fuel and lubricants, land rent, and interest on the average investment.

Cost of harvesting, hauling, and ensiling. The total labor requirement and labor cost in the wet season and in the dry season are given in table 4.

The charges for the use of equipment in the dry season and in the wet season are reported in table 5.

The total costs of ensiling for the wet season and the dry season are given in table 6.

Cost of producing silage. The cost of producing silage from one hectare of the crop, from planting to ensiling, is shown in tables 7 and 8. The wet-season yield of silage was slightly lower than that reported by Morrison [10] for the United States, which was 8 tons an acre, or 19.76 tons a hectare.

The low yield of fodder in the dry season may be attributed to lack of moisture in the soil to meet the normal requirements of the plants. Roe [11] reported that an irrigated crop gave a yield as high as 22.83 tons of silage from one acre of corn, or 56.39 tons a hectare.

This study shows a great reduction in the cost of producing corn silage in comparison with the findings of Juliano.[12] The difference was effected by the big reduction in labor requirement. Juliano reported a total labor requirement of 239.55 man hours in the wet season and 151.15 man hours in the dry season. In this study, the corresponding figures were 78.5 man hours in the wet season and 58.2 man hours in the dry season.

---

[10] F. B. Morrison, "Feeds and Feeding," 21st ed., The Morrison Publishing Company, Ithaca, New York, 1207 pp.

[11] H. B. Roe, "Moisture Requirements in Agriculture," 1st ed., McGraw-Hill Book Company, Inc., New York, 413 pp.

[12] Juliano, *op. cit.*

TABLE 1

Labor cost in raising one hectare of corn for ensiling [a]

OPERATION	WET SEASON		DRY SEASON	
	Man hours	Labor cost	Man hours	Labor cost
		pesos		*pesos*
Plowing (twice)	8.0	4.50	8.2	4.61
Harrowing (twice)	2.8	1.58	3.0	1.69
Planting	2.0	1.13	2.0	1.13
Cultivation (twice)	4.5	2.53	4.0	2.25
Total	17.3	9.74	17.2	9.68

[a] The operator received ₱4.50 an 8-hour day.

TABLE 2

Charges for use of equipment in raising one hectare of corn for ensiling [a]

EQUIPMENT	c	m	y	WET SEASON		DRY SEASON	
				Hours used	Total charges	Hours used	Total charges
	pesos	*8-hr. days*	*years*		*pesos*		*pesos*
Tractor: 24-28 h.p., kerosene, rubber tires	4,775	140	8	17.3	13.67	17.2	13.59
Plow: 2-26-in. disk	1,017	100	12	8.0	1.47	8.2	1.51
Harrow: 8-ft. double gang, 28-16-in. disk ..	700	100	12	2.8	0.36	3.0	0.38
2–4 ft. section, steel peg tooth	180	100	12	2.8	0.09	3.0	0.10
Planter: 2-row mounted .	952	60	15	2.0	0.51	2.0	0.51
Cultivator: 2-row mounted	642	80	15	4.5	0.52	4.0	0.46
Total					16.62		16.55

[a] Formulas by A. B. Catambay, Professor and Head, Department of Agricultural Engineering, College of Agriculture:

$$\text{Depreciation (per hour)} = \frac{0.97c}{8ym}$$

$$\text{Interest on average investment (per hour)} = \frac{0.97cr}{16m}$$

$$\text{Housing and repair (per hour)} = \frac{cr'}{8m}$$

where

c = cost of equipment in pesos;
y = estimated life in years;
m = estimated maximum number of days used in one year;
0.97 = 100% − 3%, 3% being considered as scrap value of equipment;
r = 7%, rate of interest charged on average investment;
r' = 3%, fixed charges on first cost a year.

TABLE 3

Cost of raising one hectare of corn for ensiling

ITEM	WET SEASON	DRY SEASON
	pesos	*pesos*
Labor	9.74	9.68
Charges for use of equipment	16.62	16.55
Seeds (6 gantas)	4.32	4.32
Fuel and lubricant for tractor and implements	23.61	23.46
Use of land at ₱70 a hectare for 6 months	35.00	35.00
Interest on average working capital at 7 per cent a year	1.51	1.50
Total cost	90.80	90.51

TABLE 4

Labor requirement and labor cost in harvesting and elevating corn fodder into silo from one hectare of the crop

OPERATION	WET SEASON		DRY SEASON	
	Man hours	Cost	Man hours	Cost
		pesos		*pesos*
Harvesting:				
operator of harvester[a]	6.8	3.83	6.5	3.66
helper	6.8	3.40	6.5	3.25
Hauling:				
tractor driver[a]	6.8	3.83	4.0	2.25
helpers (two)	13.6	6.80	8.0	4.00
Elevating:				
operator of blower[a]	6.8	3.83	4.0	2.25
Compacting of fodder in silo:				
three men	20.4	10.20	12.0	6.00
Total	61.2	31.89	41.0	21.41

[a] Tractor driver and machine operators received ₱4.50 an 8-hour day; other laborers, ₱4.00 an 8-hour day.

TABLE 5

Charges for use of equipment in silage harvesting, hauling, and filling of the silo

EQUIPMENT	*c*	*y*	*m*	WET SEASON		DRY SEASON	
				Hours used	Total charges	Hours used	Total charges
	pesos	*years*	*8-hr. days*		*pesos*		*pesos*
Tractor: 34-38 h.p., kerosene, rubber tires	5,047	8	140	6.8	5.68	6.5	5.42
Tractor: 24-28 h.p., kerosene, rubber tires	4,775	8	140	6.8	5.37	4	3.16
Tractor: 12-18 h.p., gasoline, rubber tires	3,405	8	140	6.8	3.83	4	2.25
Ensilage harvester	2,299	12	140	6.8	3.84	6.5	3.67
Blower	984	15	60	6.8	0.98	4	0.57
Wagons: (4-wheeled, rubber tires							
No. 2	850	10	100	6.8	1.16	4	0.68
No. 3	850	10	100	6.8	1.16	4	0.68
No. 4	900	10	100	6.8	1.23	4	0.72
Total					23.25		17.15

TABLE 6

Cost of harvesting, hauling, and ensiling corn from one hectare of the crop

ITEM	WET SEASON	DRY SEASON
	pesos	*pesos*
Labor	31.89	21.41
Fuel and lubricant for tractors and machinery	30.13	22.02
Charges for use of equipment	23.25	17.15
Total	85.27	60.58

TABLE 7

Cost of producing corn silage from one hectare of the crop

ITEM	WET SEASON	DRY SEASON
	pesos	*pesos*
Cost of producing the crop	90.80	90.51
Cost of harvesting and ensiling	85.27	60.58
Charges for use of silo [a]	42.97	34.37
Total	219.04	185.46

[a] Cost of silo, ₱1,375. The formulas in table 2 were used in computing charges based on 5 months' storage in the wet season and 4 months' storage in the dry season, excluding housing.

TABLE 8

Cost of producing one ton of silage

CULTURE	COST OF PRODUCING ONE HECTARE OF CROP	YIELD	COST TO PRODUCE ONE TON
	pesos	*tons*	*pesos*
Wet-season	219.04	19.10	11.47
Dry-season	185.46	12.00	15.46
Average		15.50	13.47

THE FUNGUS CAUSING BLACK KERNEL ROT OF CORN[1]

MARIA SALOME E. DEL ROSARIO

WITH SIX TEXT FIGURES

Black kernel rot of corn first becomes evident as a discoloration on the kernels. As the disease progresses, the kernels become black and show small but discernible eruptions. The leaf lesions are brown, becoming darker brown as the disease advances; they are elongate or oval in shape. The center of the lesion is straw-colored and the borders are dark brown.

The disease is caused by *Botryodiplodia theobromae* Pat. or a very closely related species. The young hyphae are septate, branched, thin-walled, hyaline, and granular; they have an average measurement of 38.09 × 4.54 microns. The pycnidia occur in clumps, rarely singly, and are black and ostiolate; their average measurement is 281.10 microns. The pycnospores are nonseptate, colorless, and granular when young; oval, brown, uniseptate, nonconstricted at the septum with longitudinal striations on the wall when mature. Their average size is 27.66 × 16.065 microns. The fungus grows luxuriantly on steamed corn meal and potato-dextrose agar. Cross-inoculation experiments showed that cacao pods are readily infected by the pathogen.

A black kernel rot of corn was observed on the corn ears harvested by the Department of Agronomy in February, 1953. The disease was again observed by the writer on a number of corn ears harvested in November, 1953, by Avelino Banaag when he tested some insecticides in the control of insects attacking corn. Most of the infected ears were found in the lot which was severely infested with corn earworm (*Heliothis armigera* Hub.). Since about thirty per cent of the ears were infected in varying degrees of severity, the disease was studied in the laboratory of the Department of Plant Pathology, College of Agriculture, from April to November, 1953.

SYMPTOMS OF THE DISEASE

Infection may start on any portion of the corn ear. In the early stage of the disease, infected kernels show a brown discoloration (fig. 1A). As the disease progresses, the kernels become black and show small but discernible eruptions, within which may be found the fruiting bodies of the fungus. When the contents of the kernels are completely invaded by the fungus, a dry rot results. On some ears only a few scattered kernels show the characteristic blackening. On others one-third to one-half the total number of kernels in the ear may be involved (fig. 2). In severe cases of infection, the fungus penetrates from the kernels into the cob.

---

[1] Central Experiment Station Contribution No. 1761. Special problem in Plant Pathology 99. Prepared in the Department of Plant Pathology under the direction of Dr. Faustino T. Orillo.

Fig. 1.—Semimature corn ears sprayed with pycnospore suspension: A, early stage; B and C, advanced stages of the disease. ×¼. (*Photographed by Star Studio, Los Baños, Laguna.*)

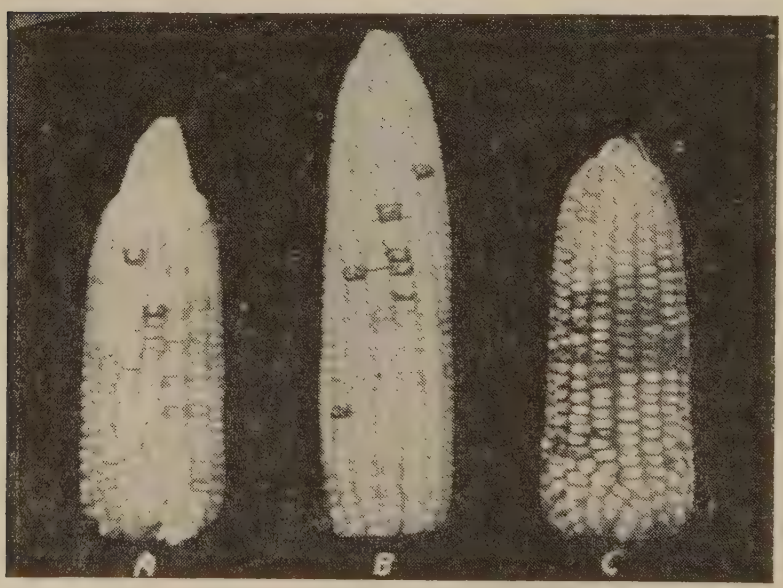

Fig. 2.—Corn ears infected in the field: A, early stage; B and C, advanced stages of the disease. ×¼. (*Photographed by Star Studio, Los Baños, Laguna.*)

CAUSAL ORGANISM

The causal fungus was isolated by planting sections of diseased corn kernels on plated corn meal agar. After four days, bits of mycelium were transferred from the fungus colonies on the plates to agar slants. Subcultures made from these transfers were used in morphological and cultural studies and in inoculation experiments.

Morphology

Mycelium. Young hyphae are septate, branched, thin-walled, hyaline, and granular. They produce a loose, flocculent, white aerial growth on agar media. As the hyphae grow older, they become

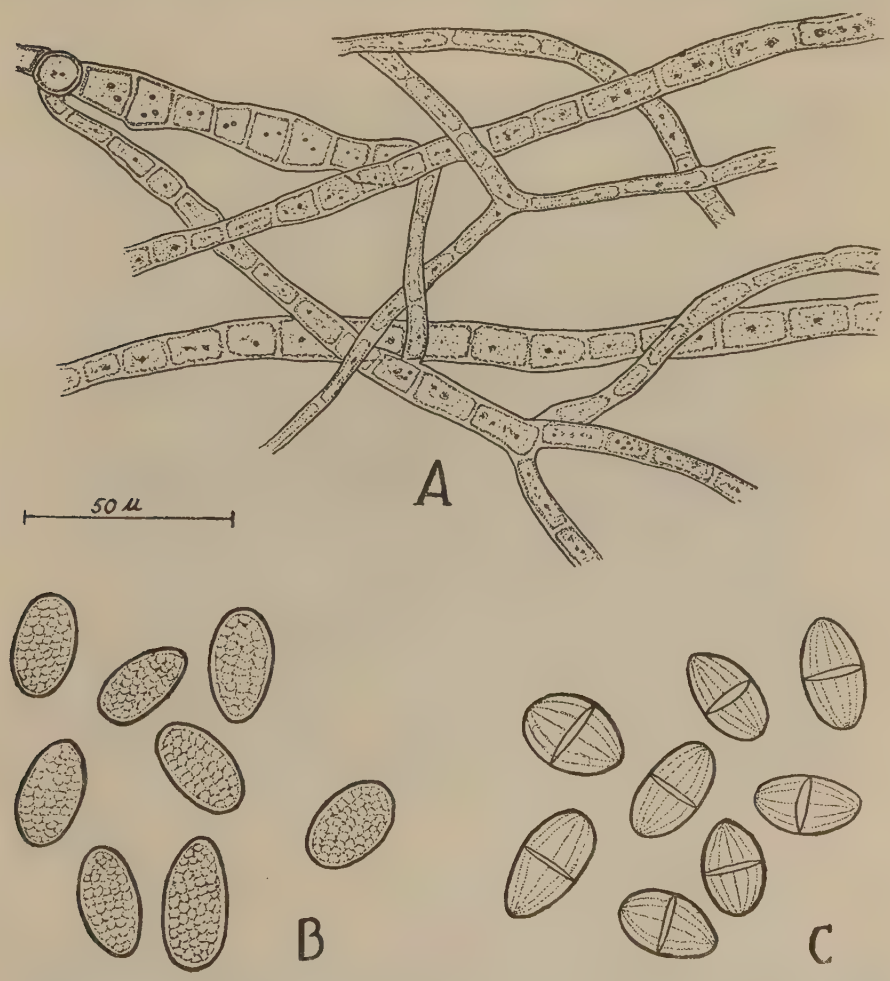

Fig. 3.—Camera lucida drawings of *Botryodiplodia theobromae* Pat.: A, mycelium; B, young pycnospores; C, mature pycnospores.

brown, thicker-walled, and vacuolate. They form knoblike structures which resemble chlamydospores (fig. 3A). Stromatic masses in which pycnidia are embedded are produced on the surface of the culture media. The mycelium eventually turns black. Measurements of 100 hyphal cells from 10-day-old cultures on steamed corn medium show that the cells are from 28 to 70 microns in length and from 3.15 to 10.50 microns in width, the average size being 38.09 × 4.54 microns.

Pycnidia. The pycnidia occur in clumps, rarely singly, on the culture medium and on infected corn kernels. They are black, superficial or slightly immersed, subglobose to globose, provided with a short beak, and ostiolate (fig. 4). Measurements of 100 pycnidia show that they range from 90 to 600 microns in diameter, with an average of 281.10 microns.

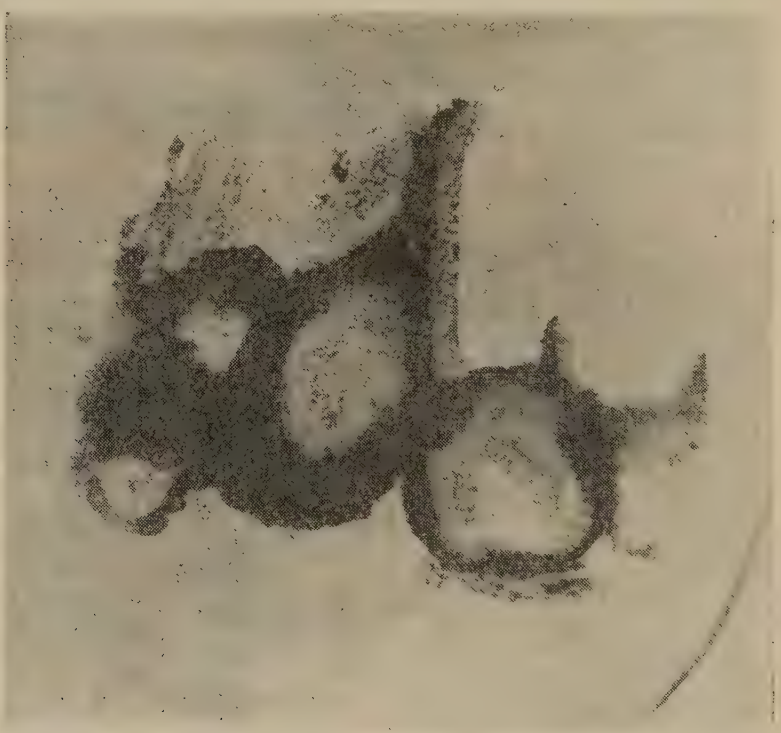

Fig. 4.—Photomicrograph of the cross section of a group of pycnidia of *Botryodiplodia theobromae* Pat. ×80. (*Photomicrographed by the Photographic Division, College of Agriculture.*)

Pycnospores. The pycnospores are borne singly on short, hyaline conidiophores within the pycnidium. When young, they are nonseptate, colorless, and granular (fig. 3B). Mature pycnospores are oval, brown, uniseptate, nonconstricted at the septum, with longi-

tudinal striations on the wall (fig. 3C). Nonseptate dark-colored spores rarely occur. Measurements of 100 pycnospores show them to range from 10.50 to 17.25 × 21.50 to 31.50 microns; their average size is 27.66 × 16.065 microns.

Physiology

The growth rate, cultural characteristics, and pycnidial production of the fungus were observed under ordinary laboratory conditions on steamed corn meal, potato-dextrose agar, corn decoction agar, rice decoction agar, and corn meal agar. The results are summarized in table 1. The fungus produced a fluffy whitish growth after 24 hours except on rice decoction agar. It showed excellent growth on steamed corn meal and comparatively good growth on the other media, except on rice decoction agar where the growth was scanty. Among the five media used, steamed corn meal was observed to be the best medium for production of pycnidia. On rice decoction agar the fungus produced few pycnidia. On potato-dextrose agar, the fungus produced abundant pycnidia and on corn meal agar, fairly abundant pycnidia.

PATHOGENICITY

The pathogenicity of the fungus was tested on corn seedlings and semimature corn ears. The effect of the fungus on germination of corn seeds was also determined by spraying the seeds with pycnospore suspension prior to planting in sterilized soil and by planting surface-sterilized seeds in infested soil.

Experiment 1. On June 22, 1953, fifteen one-week-old corn seedlings growing in potted soil were inoculated; the leaves were sprayed with a pycnospore suspension prepared from one-week-old-corn meal agar slant cultures of the fungus. A DeVilbiss hand atomizer was used to spray the inoculum. Fifteen seedlings sprayed with sterile water were used as control.

On the same day, the leaves of 15 corn seedlings were smeared with bits of agar medium containing the mycelium of the fungus. Fifteen seedlings smeared with bits of sterile agar medium alone served as control. The inoculated and control plants were kept inside a damp chamber for 48 hours and afterwards transferred outside the laboratory for further observation. Infection was noted on all inoculated plants on June 24, 1953, that is, two days after inoculation. The symptoms became much more evident within a week. Throughout the period of observation, the control plants remained healthy.

The lesions on the leaves of the inoculated corn seedlings were at first in the form of water-soaked, more or less circular spots. With age, the spots turned brown and became elongate or oval in shape. The center of the spot was straw-colored and the borders were distinctly darker brown in color. Old lesions were from 0.5 to 1 centimeter in width and 2 to 4 centimeters in length (fig. 5 and 6).

Fig. 5.—Corn plants at right were inoculated by spraying with pycnospore suspension of *Botryodiplodia theobromae* Pat. Note the lesions on the leaves. Control plants at left. ×¼. (*Photographed by the Photographic Division, College of Agriculture.*)

Fig. 6.—Corn plants at right were smeared on the leaves with bits of agar medium containing mycelium of *Botryodiplodia theobromae* Pat. Control plants at left. ×¼. (*Photographed by the Photographic Division, College of Agriculture.*)

Experiment 2. On June 9, 1953, the husks of six semimature corn ears were removed. Three ears were sprayed with pycnospore suspension and the other three were smeared with bits of agar medium with mycelium of the fungus. Controls consisting of ears sprayed with sterile water and ears smeared with sterile agar medium were maintained. The inoculated and control ears were kept inside a damp chamber for 48 hours. Three days after inoculation numerous kernels on the treated ears showed signs of infection. Brownish discoloration was noted on them. After one week, distinct blackening of the infected kernels and production of fruiting bodies of the fungus were observed (fig. 1). The controls remained healthy throughout the experiment.

Experiment 3. On August 28, 1953, forty-five corn seeds were liberally sprayed with pycnospore suspension of the fungus and planted in three pots of sterilized soil, 15 seeds to a pot. As control, 45 seeds were sprayed with sterile water and planted in potted sterilized soil. The pots were kept in the greenhouse and watered regularly. After one week the percentage of germination was determined. Of the 45 inoculated seeds only three, or approximately 6.66 per cent, germinated. The ungerminated seeds were examined and found to be invaded by the fungus and partially rotted. Apparently the fungus was the principal cause of the failure of the seeds to germinate. The control seeds gave 100 per cent germination.

Experiment 4. Three pots of previously sterilized soil were infested with the fungus. Disinfected corn seeds were planted in these pots, 15 seeds to a pot. Forty-five disinfected seeds were planted in three pots of noninfested soil to serve as control. As in experiment 3, the pots were kept in the greenhouse and watered regularly. Only seven out of the 45 seeds planted in infested soil germinated, whereas all the seeds planted in noninfested soil germinated. The fungus was present in all the ungerminated seeds and obviously caused the rotting of those seeds.

Inoculation of cacao pods. On account of the similarity of the writer's *Botryodiplodia* to the cacao fungus, cacao pods were inoculated with pycnospore suspension or with bits of agar medium with mycelium. Pods sprayed with sterile water and smeared with sterile agar medium served as control. Both inoculated and control pods were kept inside a damp chamber for 48 hours.

The writer's fungus was pathogenic to cacao; infection was noted on the pods two days after inoculation. The lesions which at first were water-soaked specks increased in size and gradually turned black. Erumpent pycnidia were produced on the blackened lesions on the pods.

TAXONOMIC CONSIDERATIONS

According to Wardlaw,[2] *Botryodiplodia theobromae* Pat. produces pycnidia that are regular, flask-shaped structures, separate or

[2] C. W. Wardlaw, "Diseases of the Banana and of Manila Hemp Plant," Macmillan and Co., London, 1935, 615 pp.

grouped together, and as a rule placed superficially or only slightly immersed. They have short straight necks and ostioles, dark, carbonized outer walls, and diameters of 250 to 300 microns; within, the conidia are borne on short conidiophores accompanied by paraphyses. The conidia, mainly extended as single cells, subsequently mature and become characteristically brown, uniseptate, striated, and unconstricted, measuring 25 × 15 microns. Saccardo [3] gave essentially the same description for *Lasiodiplodia theobromae* (Pat.) Griff. et Maubl., which is synonymous to *Botryodiplodia theobromae* Pat. except for the size of spores. The spores he measured were 20 to 30 × 11 to 15 microns.

The corn pathogen studied by the writer agrees in gross morphological characteristics with the species described by the previous investigators. The measurements of the fruiting structures of the corn fungus lie within the range given by the two previous authors. Furthermore, the symptoms that the pathogen produces on cacao pods are strikingly similar to those recorded by Saccardo.[4] The writer therefore considers the fungus causing the black kernel rot of corn identical with, or very closely related to, *Botryodiplodia theobromae* Pat.

---

[3] P. A. Saccardo, "Sylloge Fungorum," Edwards Brothers, Inc., Ann Arbor, Michigan, 1913, Vol. 22, 823 pp.

[4] *Ibid.*

TABLE 1

Growth characteristics and pycnidial production of Botryodiplodia theobromae on various culture media

MEDIUM	GROWTH CHARACTERISTICS	PRODUCTION OF PYCNIDIA	DIAMETER OF COLONY AFTER 4 DAYS [a]	AVERAGE DAILY GROWTH
			mm.	*mm.*
Steamed corn meal	Very abundant; fully white to dull white aerial mycelium produced within 24-48 hours; culture medium changed from dull orange to gray.	Very abundant	90.0 [b]	45.00
Corn meal agar	Growth spreading; mycelium white to gray; produced after 2 days; culture medium changed from pale brownish to bluish green	Fairly abundant	85.0	21.25
Corn decoction agar	Growth fairly dense especially at center within 2 days; white to dull gray; culture medium changed from brown to olive green.	"	81.0	20.25
Rice decoction agar	Growth thin; mycelium white to dull gray; medium turned from olive green to green; growth distinctly zonate.	Scarce	64.0	16.00
Potato-dextrose agar	Growth abundant; white to dull white aerial mycelium produced within 24 to 48 hours; growth at center dense and fluffy; color of medium changed from brown to olive green.	Very abundant	83.3	20.83

[a] Average of 3 cultures.
[b] Diameter of colony after 2 days.

COLLEGE AND ALUMNI NOTES

The Los Baños internment camp plaque was unveiled in a program, sponsored by the American Association of the Philippines, in front of Baker Hall last February 23, 1954. The plaque was presented by Mr. Frank Bennett and accepted by Dean L. B. Uichanco. The invocation and benediction were given by Father John J. McMahon, S.J. Other speakers were Dr. Leon G. Gonzalez and Mr. W. Harry Fonger. Mrs. Marie Janda unveiled the plaque before a large audience composed of visitors, faculty members, and students.

A regular scientific meeting of the Los Baños Biological Club was held on January 29, 1954, at the Chemistry Lecture Hall. The following papers were read and discussed: "The effect of synthetic estrogen implantation on the gain in weight and subsequent reproductive ability of young S. C. White Leghorn cockerels," by Mr. A. C. Campos and Dr. F. M. Fronda, and "Expenditures of 117 men students in the College of Agriculture, U. P., 1952-53," by Dr. L. S. Robertson and Prof. N. B. Tablante.

The Los Baños ROTC unit held its annual parade and review and presentation of sponsors in honor of the Area Commander and staff (II MA) on February 22, 1954. After the parade, short speeches commending the performance of the Los Baños cadets were delivered by Colonel Nicanor Velarde, Area Commander; Colonel Carmelo Barbero, superintendent of the Manila ROTC units; and Dr. F. M. Fronda, secretary of the College. Major Virgilio T. Almeda, commandant, introduced the speakers.

The College annual Junior-Senior Ball was held at the Seniors' Social Garden on February 13, 1954. Mr. Benjamin L. Arenas is the president and Dr. Jose M. Capinpin is the adviser of this year's junior class. The senior class has Mr. Marcos R. Vega, Jr., as president and Prof. Nathaniel B. Tablante as adviser.

The Freshman Class Organization of the College presented a much-applauded literary-musical program on the evening of February 19, 1954, at the Chemistry Auditorium. Main features of the program were two musical skits, "Charades" and "Caramba," and a one-act play, "Death at Fever Flat," by George Cronin. Godofredo C. Eala is the president and Dr. S. M. Cendaña is the adviser of the freshman class.

The Philippine Country Life Association held its "Pista Sa Nayon" program and dance on February 6, 1954, at the Seniors' Social Garden. Orlando J. Sacay is the president and Miss Dolores P. Barile, the adviser of the Association.

More than 300 students taking Zoology 1 went to Dalahican, Lucena, Quezon, last February 6, 1954, to observe and collect sea-

water animals. Dr. S. M. Cendaña, Miss V. Q. Samson, and Messrs. B. C. Gabriel and C. Madamba accompanied the students.

Mr. Jose F. Zamora, '11, was elected chairman of the Gonzalez Building Fund Campaign Committee at a meeting of a group of alumni representing various government bureaus and agencies and private entities. The meeting was held at the UNO Club restaurant on March 6, 1954, to map out the campaign for raising funds with which to build a memorial for the late President Gonzalez. The group was confident that one hundred thousand pesos could be raised by the alumni of the College, numbering about two thousand. Elected members of the executive committee were Mr. Zamora as chairman; Demetrio Santos as vice-chairman; Francisco O. Santos, executive secretary; Francisco M. Fronda, corresponding secretary; Francisco M. Sacay, treasurer; Eligio Tavanlar, Jose J. Mirasol, and Fernando Ordoveza, members.

Mr. Severo G. Yap, '22, of the New Bilibid Prison in Muntinglupa, Rizal, visited the College recently. He was formerly head of the Davao Penal Colony.

Mr. Tsui Kwok-Hing, '40, is now laboratory superintendent in the Department of Biology of the University of Hongkong, according to a letter received recently by Dr. F. M. Fronda.

Mr. Irving P. Villasor, '53, who is working at Victorias Milling Company as one of the assistants of Dr. C. Van Dillewijn, will soon leave for the United States to pursue advanced studies at Cornell University, according to his letter to Dr. J. M. Capinpin.

For the reconstruction of the records of the College, alumni who have not yet done so are requested to furnish the Secretary's office with data as to their present position, address, and other information which they may deem important for record purposes.

President Ramon Magsaysay made a surprise visit to the College on February 1, 1954. He observed the various projects in progress, particularly the dairy project. Before leaving, he talked to the students in one of the classes. He was shown around by Dean Uichanco and Secretary Fronda.

Ambassador and Mrs. Raymond Spruance and Colonel and Mrs. Harry Brenn visited the College last February 12, 1954.

Representatives from FOA, Division of Agricultural Economics of the DANR, and Department of Agricultural Economics of the College held a meeting on the campus on January 28, 1954, to discuss problems of research in agricultural economics and cooperative relations that may be developed among various agencies. Those present were Prof. Lynn S. Robertson, who acted as chairman, Mr. Isidro Macaspac, secretary, Dr. Amando M. Dalisay, Dr. Claude F. Clayton, Dr. Robert MacMillan, Prof. N. B. Tablante, Mr. Dimas Maulit, Mr. Albino P. Varona, and Dr. F. M. Sacay.

Messrs. Turner and Pineda, of the Fertilizer Administration, and Messrs. Orbena, A. Briones, '29, and A. Gesmundo, '30, of the Bureau of Soil Conservation, were recent campus visitors. The group was

accompanied by Drs. N. C. Brady and N. L. Galvez when it visited the rice and corn fertilization experiments being carried out by the UP College of Agriculture in the nearby towns.

Other recent campus visitors were Drs. Marcos Alicante and B. T. Marfori, '30, and Mr. Alfredo Barrera, '35, of the Bureau of Soil Conservation. They visited the rice and corn fertilization experiments being undertaken by the UP College of Agriculture in cooperation with the farmers. Dean L. B. Uichanco, Asst. Dean F. O. Santos, Dr. N. C. Brady, and Dr. N. L. Galvez accompanied the visitors.

The following faculty members attended the Farmers' Day held recently at the Maligaya Rice Experiment Station in Muñoz, Nueva Ecija: Dean L. B. Uichanco, Assistant Dean F. O. Santos, Dr. H. K. Hayes, Dr. V. C. Calma, Dr. D. L. Umali, Dr. J. R. Velasco, Prof. A. P. Aglibut, and Mr. L. S. Castillo.

Among the alumni who were on the program were Director G. F. Merino, '14, Dr. A. M. Dalisay, '37, Dr. Juan P. Torres, '19, and Messrs. Esteban Cada, '35, Francisco P. Octubre, '15, Felix D. Enrile, '31, and Marcelino Constantino, '16. Mr. Apolinario D. Benitez, '33, is the superintendent of the Station.

At the two hundred twenty-third scientific meeting of the Los Baños Biological Club held on February 26, 1954, the following papers were presented: "On the natural occurrence of two crystalline forms of vanillin," by Aurora T. Violanda, and "Cinchona canker incidence in relation to cinchona seedling wilt and blight diseases caused by *Phytophthora cinnamomi* Rands," by E. F. Roldan.

THE CENTRAL EXPERIMENT STATION

LIST OF AVAILABLE PUBLICATIONS

No. 2.—Bud Rot of Coconut ..... *By G. O. Ocfemia*
No. 8.—Horse Breeding in the Philippines ..... *By V. Villegas*
No. 11.—The New College Copra Drier ..... *By Moises M. Kalaw* (Revised)
No. 17.—College Trapnest ..... *By F. M. Fronda and P. S. Paje*
No. 18.—Surveying for Area with a Surveyor's Staff ..... *By Alexander Gordon*
No. 23.—Curing Pork and Making Sausage for Home Use ..... *By Mariano Mondoñedo*
No. 24.—Construction and Operation of Silos in the College of Agriculture ..... *By J. P. Esguerra*
No. 29.—Collegiate Education in Agriculture ..... *By Leopoldo B. Uichanco*
No. 30.—What Should Filipino Ornamental Gardens and Ornamental Plants Be? ..... *By N. B. Mendiola*
No. 33.—Kenaf Culture ..... *By P. A. David*
No. 34.—Vanilla Culture ..... *By P. A. David*
No. 35.—Black Pepper Culture ..... *By P. A. David*

The price of the circulars listed above is thirty centavos (₱0.30) each.

All orders for circulars with payment should be addressed to the Business Manager, THE PHILIPPINE AGRICULTURIST, College, Laguna, Philippines.

PHILIPPINE AGRICULTURE, Volume 1 { Clothbound ..... ₱10.00; Postage 0.40

Volume 2 { Clothbound ..... ₱7.00; Postage 0.40

A MANUAL OF PLANT BREEDING FOR THE TROPICS ..... ₱6.00

All orders for books with remittance should be addressed to

THE DEAN AND DIRECTOR
COLLEGE OF AGRICULTURE AND
CENTRAL EXPERIMENT STATION
COLLEGE, LAGUNA, PHILIPPINES

The Philippine Agriculturist

(Formerly The Philippine Agriculturist and Forester)

Published by the COLLEGE OF AGRICULTURE
AND CENTRAL EXPERIMENT STATION
UNIVERSITY OF THE PHILIPPINES

Vol. I—2

Vol. III—9-10

Vol. V—2, 6, 7, 9, 10

Vol. VI—1, 2, 3, 4, 6, 7, 8, 9, 10

Vol. VII—complete

Vol. VIII—3, 4, 5, 6, 8-9, 10

Vol. IX—3, 4-5, 8-9

Vol. XI—3, 7, 8

Vol. XIII—1, 10

Vol. XIV—1, 2, 3, 4, 5, 6, 7, 9, 10

Vol. XV—complete

Vol. XVI—3, 8, 9, 10

Vol. XVII—6, 7, 8, 9, 10

Vol. XVIII—complete

Vol. XIX—complete

Vol. XX—complete

Vol. XXI—complete

Vol. XXII—complete

Vol. XXIII—1, 2, 3, 4, 6, 7, 8, 9, 10

Vol. XXIV—complete

Vol. XXV—complete

Vol. XXVI—complete

Vol. XXVII—complete

Vols. XXVIII, XXIX, and XXX—burned

Vols. XXXI, XXXII, XXXIII, and XXXIV—complete

Back copies of Vols. I to XXVII sell at 50 centavos and back copies of Vols. XXXI to XXXIV sell at ₱1.50.

Consolidated index (Vols. I to XX) 50 centavos excluding postage.

Send your order to the BUSINESS MANAGER, THE PHILIPPINE AGRICULTURIST, COLLEGE, LAGUNA, PHILIPPINES.